RESEARCH TRIANGLE INSTITUTE

RTI Project 26U-1133

September 1976

Final Report

A COMPREHENSIVE REVIEW OF U.S. COINAGE SYSTEM REQUIREMENTS TO 1990

Volume II

COINAGE SYSTEM ALTERNATIVES

Prepared for

U.S. Department of the Treasury
Bureau of the Mint
Washington, D.C. 20220

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

Research Triangle Institute
Center for Development and Resource Planning
Research Triangle Park, North Carolina

RTI Project 26U-1133

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COINAGE SYSTEM ALTERNATIVES

By

David H. Stuart, Project Director
M. Anne Hill

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U.S. Department of the Treasury
Bureau of the Mint
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The opinions, findings, and conclusions expressed in this document are those of Research Triangle Institute and do not necessarily represent official positions or policies of the U.S. Department of the Treasury.

PREFACE

Unanticipated coin demand and volatile raw material prices in recent years have raised questions concerning the adequacy of coin manufacturing capacity and the high costs of providing coinage for commerce in the future. As part of its continuing planning efforts, the U.S. Department of the Treasury, Bureau of the Mint contracted Research Triangle Institute (Contract Number TM 75-1059) in May 1975 to conduct a comprehensive analysis of U.S. coinage system requirements to 1990. The purpose of the study was to review and recommend changes in Mint facilities and in coin forecasting, production planning, and distribution for the present U.S. coins and for alternatives. The impacts of various alternatives on public and private interests were assessed to develop a recommended coinage system to 1990.

A Comprehensive Review of U.S. Coinage System Requirements to 1990, the final report of the research conducted by Research Triangle Institute for the U.S. Department of the Treasury, is presented in two volumes:

Volume I, Current Denomination and Alloys

Volume II, Coinage System Alternatives

Volume I focuses upon Phase I of the research: the U.S. coinage system requirements; assuming the present coin denominations, alloys, and configurations remain unchanged through 1990. It contains an assessment of alternative forecast methodologies and presents reliable techniques for projecting long-term and short-term coin requirements. In addition the capacity and capabilities of the U.S. Mint production, distribution, and inventory system are analyzed, and mathematical models for simplifying the aggregate planning and production scheduling functions are presented, along with initial implementation results.

Volume II contains the analysis and findings of the Phase II research which focused upon the impacts of alternatives to the present U.S. coin system. The results are presented for: (1) extensive surveys of public and private interests, (2) analysis of metallurgical and economic characteristics of alternative coinage materials, and (3) estimates of the cost and performance impacts of alternative coin denominations, materials, and configurations. As a culmination of the Phase II research, recommendations for changes in the U.S. coinage system to 1990 are presented.

ACKNOWLEDGMENTS

The authors, in preparing Volume II of this report, wish to express their special appreciation for the cooperation and contributions of many persons, both within and outside the Research Triangle Institute (RTI).

Valuable, thorough, and constant professional guidance was provided throughout the course of the study by the project manager for the Department of the Treasury, Mr. John M. Buck. The cooperation and assistance of Mrs. Mary T. Brooks, Director of the Mint, and Mr. Frank H. MacDonald, Deputy Director of the Mint, have been vital to the success of this project.

The members of the Mint Study Advisory Group made valuable contributions to the overall design of the study and also aided in reviewing and revising the report. Individually, the members also generously provided their time and expertise during the analysis phase of the study.

The following consultants to RTI provided expert assistance during the study: Dr. Hans H. Stadelmaier, in the survey of metallurgical properties of candidate materials, and Dr. John A. Bailey in the assessment of the technological impacts of candidate materials.

A Coinage Study Panel, consisting of representatives of primary coinage manufacturing, distribution, and user groups, provided valuable assistance in defining alternatives and evaluation criteria. Names of the panel members are contained in Appendix A.

The following persons from various departments in Research Triangle Institute made contributions to the planning, instrumentation, data collection and analysis, quantitative modeling, and report preparation activities of the study:

Ms. Vivian E. Adkins: data collection

Mr. Philip C. Cooley: system modeling and analysis

Mr. Raymond L. Collins: production analysis

Ms. Juanita Daber: computer programming

Ms. M. Anne Hill: economic analysis

Ms. Polly M. Jackson: report preparation
Mr. Stephen A. Johnston: economic analysis
Ms. Hazel Jolley: data collection and analysis
Ms. Nancy C. Monroe: instrument design
Ms. Janet Ries: data analysis
Mr. David H. Stuart: project management and analysis
Ms. Cindy Whitaker: report preparation
Ms. Brenda Young: report preparation

TABLE OF CONTENTS

	Page
Preface	i
Acknowledgments	ii
LIST OF TABLES	ix
LIST OF EXHIBITS	xiii
CHAPTER 1 - INTRODUCTION	1-1
1.0 PURPOSE	1-1
2.0 BACKGROUND	1-1
3.0 OBJECTIVES	1-3
4.0 SCOPE OF THE STUDY	1-4
5.0 ORGANIZATION OF THE REPORT	1-5
6.0 SUMMARY OF THE FINDINGS	1-5
6.1 Alternatives to the Copper Cent	1-7
6.2 The One Dollar Coin	1-8
6.3 Other Coinage Changes	1-9
6.4 Facility Utilization	1-10
6.5 Technological Assessment	1-10
CHAPTER 2 - STUDY METHODOLOGY	2-1
1.0 INTRODUCTION	2-1
2.0 PRIMARY COINAGE INTEREST GROUPS	2-2
3.0 PRELIMINARY SELECTION OF COINAGE SYSTEM ALTERNATIVES	2-4
4.0 EVALUATION CRITERIA	2-5
5.0 SURVEY OF AFFECTED GROUPS	2-7
6.0 ALTERNATIVE MATERIALS	2-7
7.0 COMMERCIAL EFFICIENCY	2-8
8.0 DISCRIMINATION CHARACTERISTICS OF COINAGE SYSTEM ALTERNATIVES	2-8
9.0 MANUFACTURING AND DISTRIBUTION REQUIREMENTS	2-9
10.0 COST IMPACTS	2-9
11.0 RECOMMENDATIONS	2-9
CHAPTER 3 - THE COMMERCIAL EFFICIENCY OF ALTERNATIVE COINAGE SYSTEMS	3-1
1.0 INTRODUCTION	3-1
1.1 Commercial Efficiency	3-1
1.2 National Coinage Preferences	3-2
2.0 EXCHANGE EFFICIENCY	3-3
2.1 Methodology	3-3
2.2 Theoretical Versus Actual Requirements	3-9
2.3 Ranking of Alternative Denomination Sets	3-13

(Continued)

TABLE OF CONTENTS (Continued)

Page

3.0 ACCEPTABILITY OF ALTERNATIVE CHANGES TO COIN USERS. . . . 3-17
3.1 Introduction 3-17
3.2 Preferred Coin Denominations 3-20
3.3 The Elimination of the Cent. 3-24
3.4 The Introduction of a Two Cent Coin. 3-29
3.5 The Half Dollar and the One Dollar Coins 3-34
3.6 Concluding Observations. 3-37

CHAPTER 4 - EVALUATION OF CANDIDATE MATERIALS FOR COINAGE ALTERNATIVES. 4-1

1.0 INTRODUCTION. 4-1
2.0 ECONOMIC CONSIDERATIONS 4-2
2.1 Introduction 4-2
2.2 Copper 4-3
2.3 Zinc 4-6
2.4 Iron 4-8
2.5 Aluminum 4-9
2.6 Magnesium. 4-12
2.7 Manganese. 4-13
2.8 Nickel 4-15
3.0 TECHNICAL CONSIDERATIONS. 4-17
3.1 Evaluation Criteria. 4-17
3.1.1 Manufacturing Requirements. 4-18
3.1.2 Discrimination Requirements 4-19
3.1.3 Aesthetic Requirements. 4-19
3.2 Evaluation Approach. 4-19
3.3 Cent Alternatives. 4-21
3.3.1 Survey Preferences. 4-21
3.3.2 Copper-Zinc Alloys. 4-21
3.3.3 Copper Clad Steel 4-22
3.3.4 Aluminum. 4-25
3.3.5 Conclusions 4-27
3.4 Dollar Coin Considerations 4-27
3.4.1 Survey Preferences. 4-27
3.4.2 Physical Properties of the Candidate Materials 4-28
3.5 Additional Considerations. 4-29

CHAPTER 5 - DISCRIMINATION CHARACTERISTICS OF COINAGE SYSTEM ALTERNATIVES. 5-1

1.0 INTRODUCTION. 5-1
2.0 LOW-DENOMINATION COINS. 5-2

(Continued)

TABLE OF CONTENTS (Continued)

Page

2.1 Candidate Combinations of Denominations. 5-2
2.2 Size Characteristics 5-2
2.2.1 Introduction. 5-2
2.2.2 Foreign Coin Sizes. 5-5
2.2.3 Survey Preferences. 5-5
2.2.4 Compatibility with Existing Equipment 5-6
2.2.5 Recommendation for Size 5-7
2.3 Configuration. 5-7
2.3.1 Introduction. 5-7
2.3.2 Survey Preferences. 5-7
2.3.3 Preferences of the Visually-Impaired. 5-8
2.3.4 Compatibility with Existing Equipment 5-8
2.3.5 Recommendations for Configuration 5-9
3.0 THE ONE DOLLAR COIN 5-9
3.1 Introduction 5-9
3.2 Size Characteristics 5-9
3.2.1 Introduction. 5-9
3.2.2 Foreign Coin Sizes. 5-10
3.2.3 Survey Preferences. 5-11
3.2.4 Compatibility with Existing Equipment 5-15
3.2.5 Recommendation for Size 5-15
3.3 Configuration. 5-16
3.3.1 Introduction. 5-16
3.3.2 Survey Preferences. 5-16
3.3.3 Preferences of the Visually-Impaired. 5-16
3.3.4 Compatibility With Existing Equipment 5-17
3.3.5 Recommendations for Configurations. 5-18

CHAPTER 6 - MANUFACTURING RESOURCE REQUIREMENTS FOR THE CANDIDATE ALTERNATIVES TO THE PRESENT COINAGE SYSTEM. 6-1

1.0 INTRODUCTION. 6-1
2.0 FORECASTS OF COIN REQUIREMENTS. 6-1
2.1 Review of Present System Projections 6-2
2.2 Methodology for Forecasting Alternative Coin Requirements 6-4
2.3 Forecasts of Coin Requirements with a Compositional Change to an Aluminum Cent Coin. 6-8
2.4 Forecasts of Coin Requirements with the Introduction of a Two Cent Coin 6-10
2.5 Production Requirements with the Elimination of the Cent Denomination. 6-13
2.6 Comparison of the Projections of Coin Requirements for the Candidate Alternatives to the Copper Cent. . 6-14

(Continued)

TABLE OF CONTENTS (Continued)

Page

2.7 Production Requirements with a More-Conveniently-Sized One Dollar Coin. 6-18
3.0 IMPLICATIONS FOR MANUFACTURING RESOURCE REQUIREMENTS OF THE CANDIDATE ALTERNATIVES 6-20
3.1 The Coin Production Process. 6-22
3.2 Current Manufacturing Resources and Capacity 6-22
3.3 Manufacturing Requirements for the Candidate Alternatives 6-25
3.3.1 Requirements with a Compositional Change in the Cent to Aluminum. 6-25
3.3.2 Manufacturing Requirements with the Introduction of a Two Cent Coin 6-28
3.3.3 Manufacturing Implications of Eliminating the Cent. 6-29
3.3.4 Summary and Comparison of Manufacturing Requirements for the One Cent Alternatives. . 6-31
4.0 MANUFACTURING RESOURCE REQUIREMENTS WITH THE ONE DOLLAR COIN. 6-32

CHAPTER 7 - IMPACTS AND COSTS ASSOCIATED WITH IMPLEMENTING THE CANDIDATE ALTERNATIVES TO THE PRESENT COINAGE SET . . . 7-1

1.0 INTRODUCTION. 7-1
2.0 ONE CENT COINAGE ALTERNATIVES 7-1
2.1 Maintaining the Copper Cent. 7-1
2.2 Changing the Composition of the Cent to Aluminum . .
2.3 The Introduction of a Two Cent Coin. . . . . .
2.4 Elimination of the Cent Coin . . . . . .
2.5 Summary and Comparison of the Impacts of Candidate Alternatives to the Copper Cent. . . . . .
2.5.1 Impacts of Alternative Strategies . . . . . .
2.5.2 Cost Impacts. . . . . .
3.0 IMPACTS OF INTRODUCING A SMALLER ONE DOLLAR COIN. . . . .
3.1 Costs. . . . . .
3.2 Impacts. . . . . .
3.3 Summary. . . . . .

CHAPTER 8 - RECOMMENDATIONS . . . . . .

1.0 INTRODUCTION. . . . . .
2.0 ALTERNATIVES TO THE COPPER CENT . . . . . .
3.0 THE ONE DOLLAR COIN . . . . . .

(Continued)

TABLE OF CONTENTS (Continued)

	Page
4.0 OTHER COINAGE CHANGES.	
5.0 FACILITY UTILIZATION	
6.0 TECHNOLOGICAL ASSESSMENT	
APPENDIX A - COINAGE STUDY ADVISORY PANEL AND THE EVALUATION CRITERIA.	A-1
APPENDIX B - SURVEY METHODOLOGY AND EXAMPLE OF A SURVEY QUESTIONNAIRE	B-1
APPENDIX C - WORLD COIN DENOMINATIONS BY SIZE AND COMPOSITION. . .	C-1
APPENDIX D - COMPARATIVE ANALYSIS OF MINIMUM AND MAXIMUM COIN DENOMINATIONS IN THE U.S. AND SEVEN COUNTRIES	D-1
APPENDIX E - ATTENDANTS OF ONE DOLLAR COIN MEETING AT RESEARCH TRIANGLE INSTITUTE, JUNE 22, 1976	E-1
APPENDIX F - COST COMPARISON OF ALTERNATIVES TO THE COPPER CENT. .	F-1

LIST OF TABLES

Table		Page
3-1	Alternative Sets of Coin Denominations	3-4
3-2	Comparison of Minimum Number of Coins Required at Each Price for Two Sets of Coin Denominations (Method A)	3-6
3-3	Minimum Number of Coins Requires for Transactions at Each Price Between 1¢ and $1 for Ten Sets of Denominations	3-7
3-4	Minimum Number of Coins Required to Make Change for The Next Highest Denomination at Each Price Between 1¢ and $1 for Ten Sets of Denominations	3-8
3-5	Net Change in Coin Requirements Between the Current System and Alternative Sets of Coin Denominations	3-10
3-6	Comparison of Theoretical With Actual Coin Requirements	3-11
3-7	Comparison of Theoretical With Actual Coin Requirements (Excluding Cents)	3-12
3-8	Ranking of Alternative Denomination Sets by Exchange Efficiency	3-14
3-9	Estimated Public Loss Incurred With Rounding	3-16
3-10	Preferred Mix of Coin Denominations for 1980 and 1990 by Group	3-23
3-11	Combinations of Coin Denominations Preferred for 1990 by Group	3-25
5-1	Dimensions of Existing U.S. Coin Denominations	5-4
5-2	Options for Dimensions of One Cent and Two Cent Coins	5-4
6-1	Baseline Projections of Annual Coin Requirements by Denomination (in billions of coins)	6-3
6-2	Intermediate Projections of Annual Coin Requirements by Denomination (in billions of coins)	6-3
6-3	Ceiling Projections of Annual Coin Requirements by Denomination (in billions of coins)	6-3
6-4	Projection of the Circulating Stock of Cent Coins Under Alternative Attrition Assumptions (coins in billions)	6-7
6-5	Projected Cent Production Requirements With An Aluminum Cent (Coins in Billions)	6-9

LIST OF TABLES (CON.)

Table		Page
6-6	Projected Coin Requirements With the Addition of a Two Cent Coin (Coins in Billions)	6-12
6-7	Projected Coin Requirements With the Elimination of the Cent (coins in billions)	6-15
6-8	Projected Annual Coin Requirements (Billions of Coins)	6-16
6-9	Difference Between the Present System and the Candidate Alternatives in Total Projected Coin Requirements (Billions of Coins)	6-17
6-10	Projected Annual Coin Requirements With A Conveniently Sized One Dollar Coin (Billions of Coins)	6-19
6-11	Difference in Total Coin Requirements With the Alternative One Dollar Coin (Billions of Coins)	6-21
6-12	Mint Production Capacity (Millions of Coins)	6-24
6-13	Equipment Requirements for Denominations Other Than Cents	6-26
6-14	Equipment Capacity Available for One Cent and/or Two Cent Production	6-26
6-15	Manufacturing Process Requirements Under Alternative Strategies of One and/or Two Cent Coin Production	6-27
6-16	Present Capacity at the Philadelphia Mint	6-30
6-17	Equipment Requirements to Produce All Coins to 1995 With the Elimination of the Cent	6-30
7-1	Actual and Estimated Mint Costs to Manufacture Copper Cent Coins (in dollar per 100 coins)	7-3
7-2	Projections of Production, Manufacturing Costs and Annual Seigniorage for the Copper Cent (million dollars)	7-5
7-3	Projected Costs of Processing the Present Cent Coin Denomination (millions of dollars)	7-6
7-4	Estimated Mint Costs to Manufacture the Aluminum Cent (In Dollar per 100 Coins)	7-10
7-5	Projections of Production, Manufacturing Costs, and Annual Seigniorage for Aluminum Cents (million dollars)	7-11
7-6	Projected Costs of Processing the Minor Coin Denominations with Aluminum Cents (million dollar)	7-13
7-7	Estimated Costs to Manufacture Two Cent Coins (In Dollar per 100 Coins)	7-16

Table		Page
7-8	Projections of Production, Manufacturing Costs, and Annual Seigniorage for Copper Cent and Aluminum Two Cent Coins (Millions Dollars)	7-17
7-9	Projections of Production, Manufacturing Costs, and Annual Seigniorage for Copper Cent and Brass Two Cent Coins (Million Dollars)	7-18
7-10	Projected Costs of Processing the Minor Coin Denominations With the Addition of a Two Cent Coin (Million Dollars)	7-20
7-11	Coin Processing Equipment Used by Retail Firms; Estimated Replacement and Modification Costs	7-23
7-12	Coin Processing Equipment Used in Commercial Banking; Estimated Replacement and Modification Costs	7-24
7-13	Estimated Mint Costs to Manufacture Nickels and Dimes (In Dollar Per 100 Coins)	7-27
7-14	Projections of Production, Manufacturing Costs and Annual Seigniorage With the Elimination of the Cent (Million Dollars)	7-28
7-15	Projected Costs of Processing Nickels and Dimes After Elimination of the Cent	7-30
7-16	Estimated Public Loss Incurred With Rounding	7-33
7-17	Comparison of Costs Incurred by Affected Groups for One Cent Alternatives: Net Present Value of Total Costs from 1978 Through 1980 (Million Dollars)	7-37
7-18	Comparison of Costs Incurred by Affected Groups for One Cent Alternatives: Net Present Value of Total Costs from 1978 Through 1990 (Million Dollars)	7-38
7-19	Annual Seigniorage For One Cent Alternatives (Million Dollars)	7-40
Appendix		
A-1	Rankings of the Relative Importance of Criteria for Evaluating Coinage System Alternatives	A-8
B-1	Survey Response Rates	B-8
C-1	Coins With Diameters Between 19.25 mm and 21.21 mm	C-2
C-2	Coins With Diameters Between 25.5 mm and 28.0 mm	C-9
1	Exchange Rates Canada	D-8
2	Exchange Rates France	D-8
3	Exchange Rates Japan	D-9
4	Exchange Rates Mexico	D-9
5	Exchange Rates Spain	D-10

LIST OF TABLES (CON.)

Table		Page
6	Exchange Rates United Kingdom.	D-10
7	Exchange Rates West Germany.	D-11
8	Cost of Living, 1940-1971.	D-13
9	Purchase Power of the Maximum Coin Denomination, 1948-1971.	D-14
10	Consumer Price Index and Purchase Power of the Dollar: 1940-1974	D-17
11	Purchase Power of the Minimum Coin Denomination, 1948-1971.	D-19
12	Coin Stock Levels of Minimum and Maximum Denominations . .	D-25
F	Cost Comparison of Alternatives to the Copper Cent	F-2

LIST OF EXHIBITS

Exhibit		Page
1-1	Annual Production Per Capita of the Minimum Denomination in the United States and Five Countries	1-2
1-2	Organization of Phase II	1-6
3-1	Should Any Coins Currently Minted and Circulated be Discontinued?	3-21
3-2	Which Currently Minted and Circulated Coins Should be Discontinued?	3-22
3-3	Response to the Elimination of the Penny by Group	3-27
3-4	Response to the Introduction of a Two-Cent Coin by Group	3-31
3-5	Should the Two-Cent Coin Replace an Existing Denomination or Should it be an Additional Denomination?	3-32
5-1	Preferred Diameter of a $1.00 Coin	5-12
5-2	Preferred Thickness for a $1.00 Coin by Group	5-13
5-3	Preferred Weight for a $1.00 Coin by Group	5-14
6-1	Alternative Projection of Total Coin Requirements	6-5
7-1	Projected Mint Costs To Manufacture Cent Coins	7-4
7-2	Projected Total Cost Per One Cent Coin Manufactured	7-8
7-3	Projected Total Cost Per One Cent Coin Added to Circulation	7-8
Appendix D		
1	Exchange Rates - United Kingdom and Canada	D-3
2	Exchange Rates - West Germany and Mexico	D-4
3	Exchange Rates - France	D-5
4	Exchange Rates - Japan	D-6
5	Exchange Rates - Spain	D-7
6	Trend in Purchase Power of U.S. $1 and 1¢ Coins	D-21
7	Maximum Denomination Coin Stock Per Capita in the United States and Six Countries	D-23
8	Minimum Denomination Coin Stock Per Capita in the United States and Six Countries	D-24

Chapter 1

Introduction

1.0 PURPOSE

The present U.S. coinage system is not viable to the year 1990. The Research Triangle Institute (RTI) has undertaken this study for the U.S. Department of the Treasury to provide an analysis of alternatives to the current coinage system and to recommend changes so that the Bureau of the Mint and the Federal Reserve System can best meet their joint responsibility for satisfying the legitimate commercial demands of the public and the Nation's businesses for coins at a minimum cost.

2.0 BACKGROUND

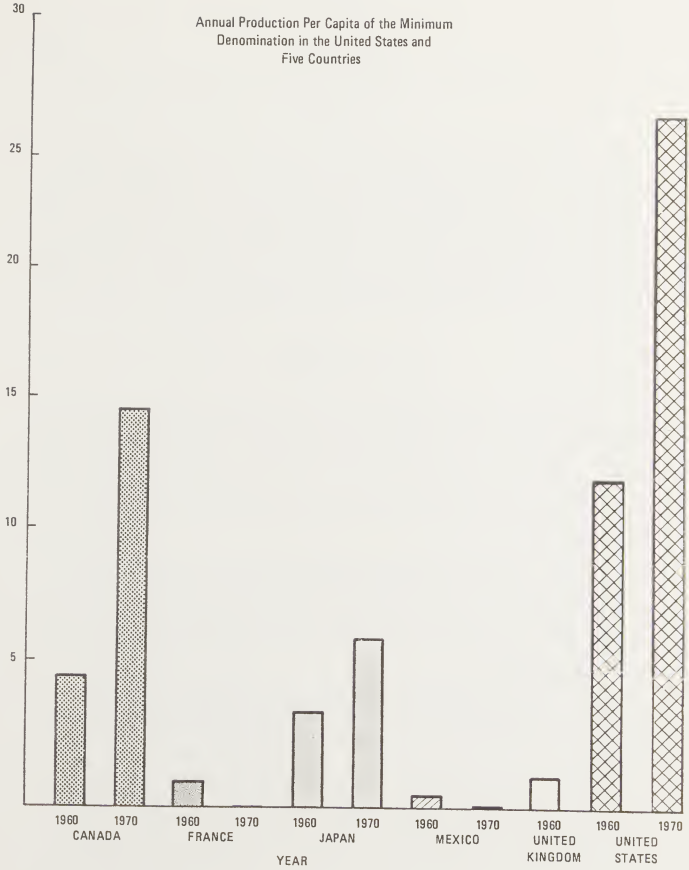
Two major problem areas exist for circulating coinage: the disproportionate requirements for cents in circulation, and the failure of the present half dollar and dollar coins to readily circulate. The production of cent coins per capita in the U.S. is more than double the production per capita of the minimum denomination of many other countries (see Exhibit 1-1).

The U.S. Government is rapidly approaching an impending dilemma due to the projected continuation of increasing cent demand and the projected increases in costs to the Mint, banks, businesses and ultimately to the public of manufacturing and distributing cents for use in commercial transactions.

By 1990 the Bureau of the Mint must more than double its coin manufacturing capacity if the current coinage system is maintained, and 90 percent of that capacity would be dedicated to manufacturing copper cent coins.

Significantly, the cent coin, which possesses negligible purchase power and has commercial value primarily as a unit of account, will dominate total coin requirements by 1990. The value of a cent, which became the smallest denomination in the U.S. in 1857 when the half-cent

Exhibit 1-1


Annual Production Per Capita of the Minimum Denomination in the United States and Five Countries
30
25
20
15
10
5
1960
1970
CANADA
1960
1970
FRANCE
1960
1970
JAPAN
1960
1970
MEXICO
1960
UNITED KINGDOM
1960
1970
UNITED STATES
YEAR

was eliminated, has declined substantially over time. The purchase power of a cent in 1917 was equivalent to that of a nickel in 1975 and to that of the projected value of a dime in 1990. The increasing nuisance aspect of cents will lead to more rapid rate of withdrawal from an expanding circulation pool, and the majority of cents produced will be replacements for cent attrition.

Compounding the dilemma, the price of copper is projected to rise to such a level by 1990 that cents may provide an economical source of copper for limited industrial consumption, leading to an accelerated rate of cent coin withdrawals from circulation. In addition, the estimated cost increases of metal, cent manufacturing, and distribution will cause a transition to negative seigniorage around 1980 which may rise to $173 million annually by 1990.

The crux of the cent dilemma is that if coin demand and economic market conditions fulfill expectations, by 1990 the Bureau of the Mint must expand production capacity by over 125 percent to produce cent coins that will be withdrawn rapidly from circulation and may cost the public $.10 each for those added to the circulating stock of cents. Eliminating the cent at that time would precipitate closing and liquidation of three-fourths of the production assets as well as termination or transferral of the majority of Mint employees.

Half dollars have an even higher annual attrition rate than cents, 22 percent versus 13 percent, and the annual attrition of one dollar coins is virtually 100 percent. Half dollar and dollar coins of a smaller size might appreciate wider circulation.

The present and impending conditions outlined above were the basis of this study to identify and evaluate alternative changes in the coinage system and to assess their impact on all components of the coinage system.

3.0 OBJECTIVES

The objectives of Phase II of the study are:

- To evaluate alternative coinage materials through analysis of their metallurgical and economic properties and production characteristics;

- To estimate the cost and performance impacts of alternative coinage denominations and materials on affected groups by personal, telephone, and mail interviews and by experimentation with coinage prototypes in coin production and processing equipment;
- To identify and rank criteria for evaluating alternative coinage systems, and select the alternative representing the set of coinage denominations and materials which is the ideal coinage system; and
- To recommend facility, operational, and management changes to facilitate implementation of the ideal coinage system through quantitative and operational analyses.

4.0 SCOPE OF THE STUDY

Phase II of the study examines the impacts of alternative coin sets on the U.S. coinage system requirements and on the public and private groups which may be affected by coin set characteristics. Throughout the report a coin set is defined as a unique combination of denominations, configurations, and material compositions of a mix of coins for use in commercial transactions. A coinage system is defined as a coin set plus the resources and activities necessary for its manufacture and distribution.

The extensive list of possible coin sets identified initially was reduced to a list of feasible coin sets based on the outcome of gross analysis of their respective economic, material, and commercial efficiency characteristics. After a more detailed examination of the feasible coin sets, a smaller list of candidate alternative coin sets was selected for an in-depth evaluation.

The most significant product of the Phase II study is the set of recommendations for forecasting, production, scheduling, and distribution for an ideal coinage system to the year 1990. Changes recommended herein may require major legislative action and/or policy changes. During the study maximum effort was expended to contact public and private groups which may be affected by changes in the system to provide

them the maximum opportunity to express their opinions. Recommendations are made for an equitable system which is as acceptable as possible to all affected parties.

5.0 ORGANIZATION OF THE REPORT

The coinage study Phase II report contains eight chapters. Following the introductory chapter, the study methodology and a summary of the major conclusions and recommendations are presented in Chapter 2. The remaining chapters present the coinage system analyses in the sequence illustrated in Exhibit 1-2. As the exhibit illustrates the various project tasks were conducted in an order designed to systematically narrow and evaluate the range of coin set alternatives towards selection of the most efficient and effective coinage system to the year 1990.

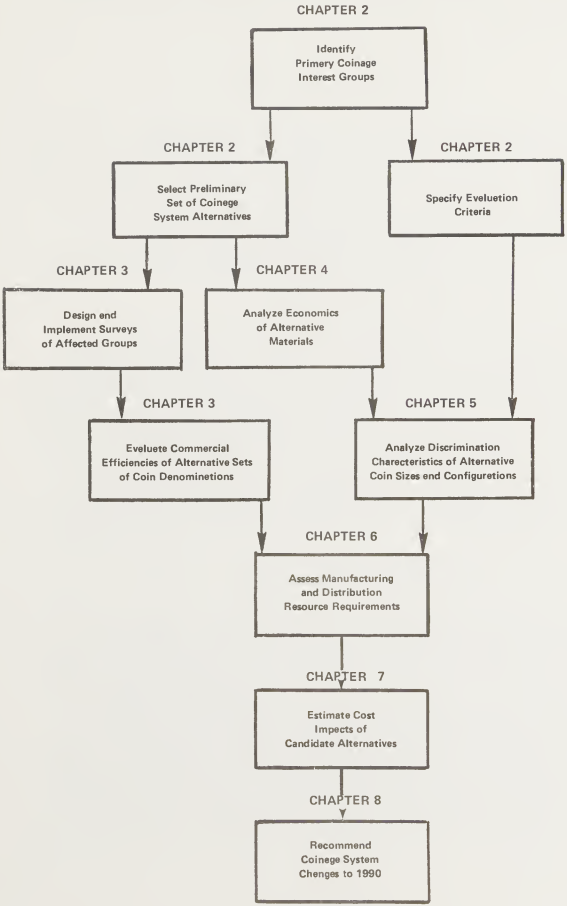
Chapter 3 presents the evaluation of the commercial efficiency of alternative sets of coin denominations. Chapter 4 contains an analysis of the economic and technical characteristics of various coinage materials. Chapter 5 presents the description and analyses of relevant discrimination characteristics for alternative coinage sizes and configurations. Chapter 6 assesses the manufacturing and distribution resource requirements of the candidate alternatives to the present coinage system. The cost impacts of these alternatives are presented in Chapter 7; and finally in Chapter 8 recommendations for the "ideal coinage system" are presented.

6.0 SUMMARY OF THE FINDINGS

Transition from the present U.S. coinage system is inevitable. To produce all the coins required to 1990 will place significant resource and cost burdens on U.S. citizens relative to the benefits gained. The problems with existing coinage, the disproportionate requirements for one cent coins, and the failure of the half dollar and one dollar coins to circulate readily are discussed throughout this study report. A wide range of alternative coin denominations, materials, sizes and configurations, were examined for their relative effectiveness as solutions to

Exhibit 1-2

Organization of Phase II



these problems. Comparing the exchange efficiency of various sets of coin denominations indicated that a two cent coin would be the most efficient denomination between the cent and the nickel. Through analysis of the economic and technical considerations of alternative materials, aluminum was selected as the most desirable material for both the one and two cent coins. To insure the greatest compatibility with existing coin validating and processing equipment, any new coins should be round.

6.1 Alternatives to the Copper Cent

If the current coinage set is to be maintained, the Mint must more than double its capacity by 1990. Over 90 percent of that capacity would be utilized in manufacturing copper cents. The majority of those cents produced would only be replacements for attrition. The alternatives found to be the most effective solutions to this dilemma included: changing the material composition of the cent from copper to aluminum; introducing an aluminum two cent coin to cocirculate with the copper cent; and eliminating the one cent coin entirely.

RTI finds the most effective and efficient alternative to be the elimination of the cent coin by 1980. This selection is based on the relative cost and acceptability of this option when compared with the other two alternatives. With each of the other options, the Mint would have to expand its capacity, requiring extensive capital investment in manufacturing equipment and production facilities, to produce coins that would, with continuing inflation, soon be valueless. Resolution of the dilemma at that time would require terminating production of the valueless coins and would result in displacement of the facilities that had been constructed, the capital resources that had been acquired, and the employees that had been hired during the interim.

This alternative - elimination of the cent - was generally viewed as unacceptable by the surveyed groups of coin users, due to the perceived impacts on commercial transactions and uncertainty about inflationary and administrative impacts. This view was also a function of their resistance to change. Change, however, is inevitable for the cent and its elimination is deemed the most economical alternative.

If having the nickel as the minimum denomination is viewed as unacceptable, only a marginal cost differential exists between the other two options of introducing an aluminum two cent coin and changing the material composition of the one cent coin to aluminum. Of these two options, the latter is preferred since it would be less complicated for the coinage system as a whole.

Immediate implementation of a strategy to eliminate the cent is not necessary. Positive seigniorage for the copper cent is projected to 1981, although the total cost of manufacturing, distributing, storing, and providing cents for commerce already exceeds the coin's face value. However, total coin requirements with the present mix of denominations will exceed manufacturing capacity by 1980. Unless positive action is taken soon to expand capacity, a cent shortage will begin by 1980 or a suboptimal production strategy will be necessary.

Unless copper prices rise to an unanticipated level, the strategy to eliminate the cent may be implemented as late as 1980 without incurring excessive costs. Foregoing capacity expansion at present is tacit recognition of the inevitability of change without declaration of the intent to change.

Public awareness of an intent to eliminate the cent will manifest itself in accumulation of cent inventories by businesses and cent hoarding for speculative purposes by individuals. This awareness will be heightened by any request for Congressional action to change the present coin system by the Department of the Treasury.

Recognizing the interim effects of cent hoarding, RTI recommends that the Department request, at the earliest reasonable date, Congressional approval to terminate manufacturing cent coins prior to 1979. A phased reduction rather than immediate termination of cent production is also recommended to smooth the transition and to allow for an orderly reduction and consolidation of Mint production resources.

6.2 The One Dollar Coin

At present, commercial utilization is poor for half dollar and nonexistant for dollar coins, due to their cumbersome sizes and the

ready availability of convenient substitutes (two quarters for the half dollar and dollar note for the dollar coin). The alternatives are to continue manufacturing the present coins or to reduce the size of, or eliminate, the half dollar and/or the dollar coins.

RTI recommends that legislation be sought to eliminate the half dollar from circulation and reduce the size of the dollar coin. The new dollar should be of a cupronickel clad or copper material, round, 26.54 mm. in diameter, 2.03 mm. thick, and possess a distinctive edge characteristic (to be designed by the Bureau of the Mint) for mechanical discrimination. These specifications represent the consensus of the primary manufacturers of coin validating and processing equipment as being the optimum for coin discrimination.

The Department of the Treasury should conduct a vigorous campaign to educate the public about the changes prior to and simultaneous with the introduction of the small dollar. However, initial success of the coin in circulation will depend heavily on the speed and extent of the automatic merchandising industry's response. The coin will circulate successfully only if it provides a means to effectively and conveniently broaden the transaction capabilities of consumers. It should not be forced into circulation by artificial restriction of the availability of one dollar notes.

6.3 Other Coinage Changes

No other changes in the size, configuration, or denomination of U.S. coins were determined to be warranted due to the acceptability and efficiency of the remaining coins--and the capital commitments of the public and private sectors to them. However, one other change warrants additional anlaysis.

No direct usage exists for the scrap material from the manufacture of clad coinage. A portion of this 93 percent copper-7 percent nickel scrap could be used economically to manufacture the nickel coin which is now made of a 75 percent copper-25 percent nickel alloy. Replacement of the present material with the clad scrap would utilize the scrap material and would result in a less costly nickel. The coin's appearance would have a reddish cast that would be aesthetically

acceptable, and the coin would be compatible with existing coin processing equipment.

On the basis of the economic gains and material handling advantage, immediate further experimental testing of the nickel alternative is recommended.

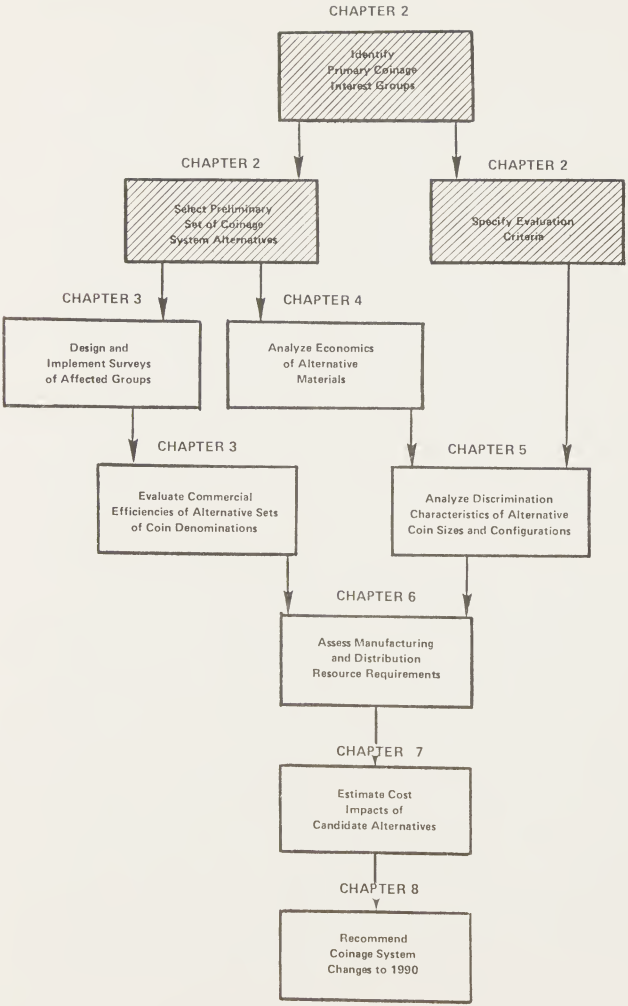
6.4 Facility Utilization

If the recommendations to eliminate the cent and half dollar and reduce the size of the dollar are implemented, the Bureau of the Mint will have manufacturing capacity in excess of its requirements to the year 2000. The production of coin for production should then be consolidated at a single mint facility; preferably the Philadelphia Mint which is the newest and largest of the two U.S. Mint facilities in operation.

With excess capacity, the Bureau of the Mint can continue its operation as a fully vertically integrated manufacturing enterprise. However, if elimination of the cent is deemed an unacceptable alternative, then the Mint should seriously consider foregoing the manufacture of intermediate materials and products in order to increase the resources available for its mandated tasks: the manufacture of coins and coin dies. Items manufactured by the Mint which could be purchased from the private sector include: coin bags; coin boxes; penny bronze; cupronickel and clad strip; and, to a lesser extent, commemorative medals.

6.5 Technological Assessment

The Office of Technology of the Bureau of the Mint has done an excellent job, with limited resources, of assessing requirements and evaluating alternatives for technological change in the dynamic environment of the past decade. The future environment is anticipated to be no less dynamic. Evaluations of manufacturing and metallurgical technology will require ongoing assessments of new potentials for coinage. In order to maintain the necessary capabilities for technological assessment it is recommended that the resources of the Office of Technology be expanded by the addition of at least two analysts.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design and Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 2

Study Methodology

1.0 INTRODUCTION

The RTI study team completed a wide range of tasks directed towards selecting candidate alternatives to the current U.S. coinage system and evaluating their relative effectiveness. Initially, RTI identified the leaders of the primary groups affected by potential changes in the coinage system and obtained their assistance as members of the Coinage Study Advisory Panel. This panel identified and ranked the relevant criteria for evaluating alternatives to the present coinage set. These criteria provided a basis to assess the cost and performance aspects of coinage system alternatives.

The exchange efficiencies of different sets of coin denominations were estimated by calculating the number of coins of each denomination necessary to facilitate commercial transactions. Extensive personal and telephone interviews and mail surveys of representatives of the potentially-affected groups were conducted to ascertain both their preferences and the impacts of coinage changes on their organizations.

Alternative coinage materials were analyzed with respect to future availability, projected price, and metallurgical characteristics. Forecasts of coinage requirements for the candidate alternatives were calculated and translated into facility requirements based on data generated from production experiments conducted by the Bureau of the Mint.

Exhibit 1-2 presented a schematic overview of these tasks and their interrelationship. When the project was initiated a multitude of alternatives was considered. Through preliminary review and analysis, this number was reduced to a manageable level. Through the course of this study, the alternatives were narrowed down to an ultimate recommendation for the "ideal coinage system." In the remainder of this chapter, the methodology for each of the tasks involved in the selection of this best-compromise system is discussed in turn.

2.0 PRIMARY COINAGE INTEREST GROUPS

Modifications in the denominations, configurations or material compositions of U.S. coins may affect the attitudes of users toward and the compatibility of coin processing and handling equipment with the resulting coin set. Changes in coin usage patterns will transmit impacts throughout the coin manufacturing and distribution pipeline: consisting of the Bureau of the Mint manufacturing, storing, and then distributing coins to the Federal Reserve banks and branches; the FRB in turn storing coin and filling coin orders placed by commercial banks; and commercial banks supplying the needs of retail businesses and consumers by providing coins for exchange in commercial transactions.

In order to assess the impacts of alternative changes in the U.S. coinage system on public and private interests, the primary groups which could be affected by changes were identified, and representatives of these groups were requested to participate in the study. The Bureau of the Mint and the Federal Reserve Banks respectively are wholly responsible for the manufacture and distribution of coin to the private sector. However, representatives of the multitude of private interests were not so specifically identifiable.

While nearly all individuals and business firms use coins to some extent in conducting financial transactions, the organizations which would incur the greatest impact from changes in a coinage set are those that employ automatic equipment for receiving, processing, and distributing coinage. Automatic coinage processing systems lack the flexibility inherent in manual systems to accommodate changes.

Consumers are the ultimate users of coin. Unfortunately, a statistically reliable household survey of consumer attitudes and preferences towards coinage alternatives was not feasible within the constraints of the study, so their opinions were not solicited directly. However, consumers conduct their transactions with businesses, and many of the businesses polled furnished their assessment of the acceptability of coinage alternatives to consumers.

Retail sales business firms constitute a primary group which could be affected by coinage changes. Specific classes of retail firms were identified as high impact classes due to their commitment to automated

coin handling and processing equipment. These firms were characterized as having large volumes of low price cash transactions, such as discount stores, or by relatively homogenous facilities dispersed across a wider geographic area, such as a fast food chain.

Commercial banks use various types of equipment related to counting or sorting coins. Banks also constitute a critical link in the coinage delivery system. Perhaps more importantly this segment of affected users could describe anticipated problems, likely changes that the introduction of new coins would create, and their impressions of consumer acceptance for alternative coins.

Automatic merchandising firms constitute the unique industry of businesses relying upon person to machine transactions. Significant issues affecting this industry include the potential markets for automatic merchandising transactions associated with alternative coin denominations and the potentials for spurious vends or jamming that may be associated with different coin configurations.

Manufacturers of coin processing equipment produce the equipment which is necessary for automatic merchandising transactions. This industry includes producers of all types of coin equipment that validate, sort, count or make change for coins. Since the existing coin processing equipment is designed within close tolerances to identify and process denominations of U.S. coins in a specific manner, any changes in coin denominations or configurations may significantly impact the industry. As with the automatic merchandising firms, the manufacturers of coin equipment are concerned about the compatibility of coin alternatives with existing equipment and in the event of incompatibility, the extent and cost of necessary modifications.

Transportation systems operators handle large volumes of coins collected as transit fares. Fares are often collected automatically, and the collected fares are processed mechanically. Consequently, this segment of coin users was contacted to ascertain the impact that changes in the coinage system would have on transportation fare collection and processing.

State Departments of Revenue are responsible for the administration of state sales taxes, and as such are likely to be aware of potential impacts in sales tax collection that would result from coinage changes.

Other groups which have a special interest in specific attributes of the U.S. coinage system include organizations representing visually impaired persons, who are concerned about physical discrimination of alternatives; numismatic organizations, which are interested in distinguishing characteristics of coins; and medical organizations, which are concerned with potential health hazards of alternatives.

3.0 PRELIMINARY SELECTION OF COINAGE SYSTEM ALTERNATIVES

Four major classes of change are relevant to this study: changes in coinage size, configuration, materials content, and denomination. Inherent in the classifications are changes in physical properties such as weight, color, durability, and magnetic properties.

The extent of analysis for classes of change has varied among the candidate alternatives according to preliminary judgments of the potential feasibility and desirability of any particular change and according to conclusions reached during the initial stages of evaluation. For example, the larger denominations of coins, particularly the half dollar and one dollar coins, are candidates for a change in size. At the same time a change in size for the lower denominations of coins appears to serve no useful purpose. It should be emphasized that change itself is not an end goal of this study, and would be recommended only for pragmatic reasons.[1/]

The two problem areas with the current coinage system are the disproportionate cent requirements and the negligible circulation of the half dollar and one dollar coins.

The primary options for one cent alternatives were determined to be:

- Maintain the existing mix of coin denominations and compositions until the level of production or the losses from negative seigniorage become prohivitive;
- Replace the 95 percent copper - 5 percent zinc cent with an alternative material.

[1/] An addition of a new denomination or a dramatic change in a current denomination obviously will require a new design for the obverse and reverse sides of the coin. Such a design effort is beyond the scope of this study, and it is assumed that where such an effort is deemed appropriate, the Department of the Treasury will arrange for its satisfactory accomplishment.

- Add a two cent coin to the existing denominations to reduce the projected number of cents required for commercial transactions.
- Eliminate the cent denomination from circulation.

For the half dollar and one dollar coins the primary options are:

- Maintain the existing mix of coin denominations and compositions.
- Eliminate the one dollar and/or the half dollar coins from circulation.
- Replace the existing one dollar coin with a smaller, one dollar coin and eliminate the half dollar from circulation.

4.0 EVALUATION CRITERIA

Recognizing that groups which might be significantly affected by changes in the U.S. coinage system should be kept informed about the alternatives under consideration, and should be provided the opportunity to offer comments, suggestions, and information about candidate changes, RTI identified key individuals from the primary groups potentially affected by such changes. RTI contacted selected key individuals to explain the purpose of the project and to solicit their participation in the selection of evaluation criteria, as well as other appropriate activities. These individuals composed the Coinage Study Advisory Panel. This panel included members representing commercial banks, retail firms, manufacturers and users of equipment for coin processing and handling, and numismatists.[1/] Opinions were also solicited from Mint and Federal Reserve Bank representatives.

Active participation of this panel was required in order to select the evaluation criteria. The first step in this task involved polling the members of the committee for their suggestions for alternatives to the current coinage system that should be analyzed, and their recommendations of specific and general criteria that should be considered in evaluating the suggested alternatives. The responses to this polling were combined to synthesize a list of nine relevant criteria. These criteria were the basis for evaluating the desirability and/or feasibility of candidate alternatives including:

[1/] Consult Appendix A for a list of the members of the Advisory Panel as well as other information relevant to the selection and ranking of the evaluation criteria.

- Public Acceptability - Convenience to individuals; based on coin size, weight, and ease of manual or visual discrimination among denominations.
- Seigniorage Protection - The extent to which the face value of a coin exceeds its material plus manufacturing costs.
- Eddy Current Discrimination - The degree to which a coin may be discriminated from other coins or slugs in a magnetic field.
- Durability - The ability of the coins to withstand wear resulting from use in circulation.
- Aesthetic Appearance - Attractiveness of form, design, and color; susceptibility to tarnishing or corrosion.
- Commercial Efficiency - The extent to which the mix of coin denominations are convenient and useful for commercial transactions.
- Mechanical Discrimination - The degree to which a coin may be discriminated from other coins or slugs through tests of its mechanical properties.
- Compatibility with Existing Equipment - The extent to which coin alternatives may be processed in existing coin validators, counters, sorters, changers, packagers, and other processing or storage equipment.
- Cost - Total manufacturing and distribution costs of the coin system.

The nine criteria were not equally relevant to the two major problem areas. Through a second polling, the members of the Advisory Panel were asked to assist in determining the relative importance of the criteria with respect to each of the major problem areas by ranking the criteria and weighting their importance. These rankings are included in Appendix A.

These criteria constituted the basis for evaluating the candidate alternatives and ultimately selecting the ideal coinage system. The tasks outlined in the following sections of this chapter, and described in more detail in the report, were undertaken to ascertain the extent to which the candidate alternatives satisfy the relevant criteria.

The relative effectiveness of the candidate alternatives for satisfying several of the criteria cannot be easily measured by cost calculations. Eddy current discrimination, durability, aesthetic appearance, mechanical discrimination, and to some extent compatibility with existing equipment, are based primarily on the materials content of the coin. Consequently, these criteria are treated in the analysis of technical considerations of alternative coinage materials. Conversely, manufacturing and distribution costs are quantifiable. Therefore, the degree to which these last criteria are satisfied was measured by the costs and/or benefits accruing to affected sectors.

5.0 SURVEY OF AFFECTED GROUPS

Market research was conducted to measure the relative impacts of alternative changes on the groups most likely affected by modifications in coin specifications. The method of conducting market research in this context was to present several proposed changes in the coinage system to users and elicit their preferences and reactions to potential changes. This was accomplished through the use of questionnaires mailed to each of the selected target groups of coin users. Appendix B contains more detailed information concerning the methodology of this survey.

6.0 ALTERNATIVE MATERIALS

RTI investigated the feasibility and efficiency of utilizing alternative materials to produce current or proposed denominations of coins. With respect to their physical properties and availability, the prospective materials were evaluated according to the relevant criteria.

The primary candidate materials were then analyzed and evaluated according to their availability to 1990, anticipated market prices, the availability of commercial suppliers, and Mint capabilities to produce sufficient coinage strip.

7.0 COMMERCIAL EFFICIENCY

As a step in narrowing the choices for the most acceptable set of coin denominations, the "commercial efficiency" for several sets of coin denominations was ascertained. The commercial efficiency of a coinage system is the extent to which it facilitates commercial transactions. It depends upon the number and variety of coin denominations themselves, the configuration of the individual coins, their acceptability to coin users, and their availability. The focus here was on two aspects of commercial efficiency: the "exchange" efficiency; that is, the denominations themselves and the manner in which they facilitate transactions; and the preferences of the selected groups of coin users elicited through the survey.

Even if a particular set of coin denominations facilitates transactions efficiently in theory, the actual commercial efficiency will in part be determined by the acceptability of the coins to groups of coin users. Therefore, survey research was required to measure the commercial efficiency of any alternative changes in the coinage system.

8.0 DISCRIMINATION CHARACTERISTICS OF COINAGE SYSTEM ALTERNATIVES

Discrimination depends on the degree to which a particular coin denomination may be identified, selected, and appropriately responded to as distinct from other coin denominations, foreign coins, and slugs. Discrimination can be facilitated by a coin's distinctiveness of material composition, color, weight, diameter, thickness, shape, and surface or edge characteristics. The purpose of this task was to evaluate the candidate alternatives to the coinage system with respect to their discrimination characteristics and to select the most feasible characteristics based on the evaluation criteria.

9.0 MANUFACTURING AND DISTRIBUTION REQUIREMENTS

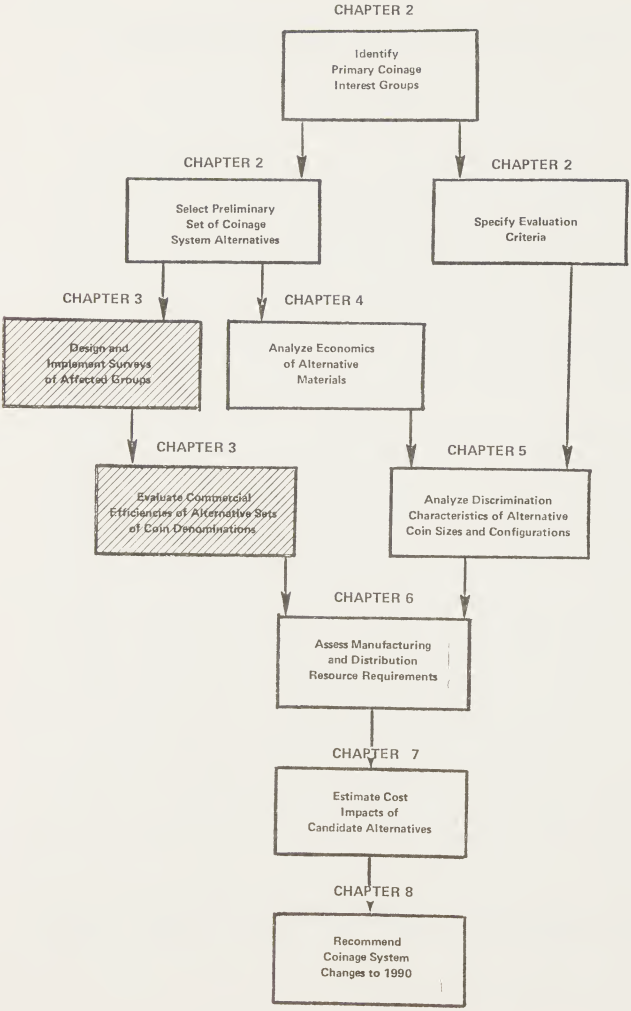
RTI developed alternative forecasts for denominations affected by changes, assuming various rates of exchange efficiency. One hundred percent efficiency implies that the total number of coins used in making change is minimized. These forecasts of coinage requirements for the candidate alternatives were developed and translated into facility requirements, to examine the impact of the alternatives on the production, distribution, and inventory systems.

10.0 COST IMPACTS

Two types of costs were calculated and compared for each of the candidate alternatives. The transition costs are the initial one-time or unique costs (capital, obsolescence, or startup) associated with a conversion from the present system to an alternative. These were considered to be the costs incurred through 1980. The long-term costs are those which would be mainly incurred after the transition. A comparative analysis of these costs to the year 1990 was performed.

11.0 RECOMMENDATIONS

After the most preferred mix of coinage denominations and content was established by eliminating alternatives through the described process, recommendations concerning appropriate changes in the coinage forecasting, production, and delivery systems were developed.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design and Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 3

The Commercial Efficiency of Alternative Coinage Systems

1.0 INTRODUCTION

1.1 Commercial Efficiency

The commercial efficiency of a coinage system is the extent to which the combinations and specifications of the coin denominations are convenient and useful to facilitate commercial transactions. Commercial efficiency depends upon the number and variety of coin denominations themselves, the configuration of the individual coins, their acceptability to coin users, and their availability. The focus here is on two aspects of commercial efficiency: the "exchange" efficiency; that is, the denominations themselves and the manner in which they facilitate transactions; and the preferences of selected groups of coin users.

Choosing the optimal coin denominations involves finding a balance between a limited number of denominations, each circulating in substantial quantities, and a large number of different coin denominations with fewer of each in circulation. Theoretically, if all amounts of payment occurred with equal frequency, the most efficient system would be binary. In this system, each value is twice the preceding value, for example, 1, 2, 4, 8, 16, 32, and so on. However, in a decimal system, the binary system is ackward and requires modification. The modifications yielding a similar configuration consists of 2, 2, 2-1/2, rather than the 2, 2, 2, in the binary system. The resulting values are 1, 2, 5, 10, 20, 50, 100. This latter system is essentially the one currently used in the U.S. with the exception of the 2 and 20 cent coins.[1/]

Even if a particular set of coin denominations facilitates transactions efficiently in theory, the actual commercial efficiency will in part be determined by the acceptance of the coins by groups of coin users. Retail businesses, banks, and other industries or groups of persons may be

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[1/] See The Feasibility of Reintroducing the Two Dollar Bill: A Marketing Approach. Boston: Graduate School of Business Administration, Harvard University, Section I.

affected by changes in coin denominations. Market research is required in order to measure the acceptability of any alternative changes in the coinage system. The method utilized to conduct market research in this context was to present several proposed changes in the coinage system to users and elicit their preferences with respect to these changes.[1/]

1.2 National Coinage Preferences

The coinage system in use throughout the world were reviewed to determine which increments in the values of denominations are most frequently used. One hundred-fifty one countries were surveyed.[2/] Of those countries, 50 use a set of denominations which contain 1, 2, 5, 10 as the increments of value for their lower valued denominations.[2/] That set was followed in frequency by 1, 5, 10; a set in use by 45 countries. The third most popular set was 5, 10; in use by 23 countries.

Those sets of denominations were followed in frequency by 1/2, 1, 2, 5, in use in 13 countries and 2, 5, 10, in use in 4 countries. Only 2 countries used any combinations of coin denominations that included 3 as a unit.

A review of the nine largest coin using countries revealed a wide range of denomination sets in use as shown below:

Nation	Total Coins Manufactured in 1973	Denomination Increments in Use
United States of America	9,765,828,405	1,5,10,25,50,100
Japan	4,440,970,000	1,5,10,50,100
India	2,111,864,514	1,2,3,5,10,25,50
Germany(FDR)	1,261,426,431	1,2,5,10,50,100,500,1000
Canada	848,197,057	1,5,10,25,50,100,500,1000
United Kingdom	786,389,186	1/2,1,2,5,10,25,50
Mexico	693,879,000	1,5,20,50,100,500,2500
Brazil	682,503,000	1,2,5,10,20,50,100,2000,30000
China(Taiwan)	604,286,000	10,20,50,100,500

1/ See Appendix B for a more complete description of this market research.

2/ U.S. Department of the Treasury, Annual Report of the Director of the Mint for the Fiscal Year Ended June 30, 1974, Document No. 3267, U.S. Government Printing Office, Washington: 1975.

Among the nine largest coin manufacturing countries, the denominations ranged in number from 5 in Japan and China (Taiwan) to 9 in Brazil; in value they range from the maximum unit being 30000 times the value of the base unit in Brazil to 50 times the minimum in China (Taiwan). All sets except 2 include a base unit of 1, eight include a denomination which is 5 times the value of the base unit, and 5 sets include a denomination valued at twice the base unit. Only one country, India, has a denomination valued at 3 times the base unit.

The denomination sets described above illustrate the types of coinage system which are in use throughout the world. In Chapter 3 the exchange efficiency of alternatives sets of coin denominations is examined, and the acceptability of selected alternatives to target groups of coin users is discussed.

2.0 EXCHANGE EFFICIENCY

2.1 Methodology

Several methods may be employed to measure the exchange efficiency of a coinage system. Two methods were used here. The first, method A, involved calculating the minimum number of coins required to facilitate transactions at each price between one cent and one dollar. The second, method B, was the calculation of the minimum number of coins required to give change from the next highest denomination at each price between one cent and one dollar. The use of either of these methods as a measure of exchange efficiency assumes that all transactions utilizing coins within this range occur with equal frequency. (The dollar values may vary, e.g. $4.04, as well as $0.04.) The calculations for methods A and B were performed for each of the sets of coin denominations included in Table 3-1.

The first set of coin denominations simply represents the present system. Other sets differ by the addition of a two cent coin, or the deletion of a currently minted denomination. A twenty cent coin replaces the quarter in set 8. Set 8 represents the theoretically optimal denominations as discussed earlier.

Several other sets of denominations including 2-1/2 cent and 12-1/2 cent coins were initially tested. However, these sets would be commercially inefficient (i.e., more coins would be required than with the current system). Consequently, these sets were not further analyzed.

Table 3-1

Alternative Sets of Coin Denominations

Denomination Set Number	Coin Denominations						
1	1¢	-	5¢	10¢	25¢	50¢	$1.00
2	1¢	2¢	5¢	10¢	25¢	50¢	$1.00
3	-	2¢	5¢	10¢	25¢	50¢	$1.00
4	1¢	-	5¢	10¢	25¢	-	$1.00
5	1¢	2¢	5¢	10¢	25¢	-	$1.00
6	1¢	-	5¢	10¢	25¢	-	-
7	1¢	2¢	5¢	10¢	25¢	-	-
8	1¢	2¢	5¢	10¢	20¢	50¢	$1.00
9	1¢	-	5¢	10¢	20¢	50¢	$1.00
10	-	-	5¢	10¢	25¢	50¢	$1.00

A 3 cent coin would be only slightly less efficient than a 2 cent coin. However, contemporary coinage systems utilizing a 3 cent coin are rare (in current use in only 2 of 151 countries reviewed) and no organization surveyed recommended its use. Thus, the 3 cent coin was also excluded from further consideration.

The objective of the exchange analysis was to ascertain whether alternative denominations would increase or decrease the quantity of coins required for commercial transactions. The cumulative numbers of coins required for the transactions outlined in methods A and B for alternative sets of denominations were compared to the comparable numbers of coins required with the present coinage system. A decrease over the total number of coins used with the current system would therefore translate into increased exchange efficiency and less production requirements.

To illustrate the calculations involved, Table 3-2 compares the minimum number of coins required for transactions at each price between one cent and twenty-five cents (method A) for the present coinage system to the minimum number of coins required at each price for denomination set 2. Both of these denomination sets include half dollar and dollar coins, but their use is unnecessary for the transactions illustrated. As may be inferred from this table, the use of a two cent coin substantially reduces the total number of coins required by decreasing cent requirements.

Tables 3-3 and 3-4 contain the cumulative number of each coin denomination required to facilitate the transactions with each of the ten candidate sets of denominations. As may be seen in either table, the elimination of the cent altogether results in the most dramatic decrease in the number of coins. However, this elimination would require rounding total transaction prices to five cent increments; and 80 percent of current transactions would require some adjustment. The set of denominations requiring the next fewest coins includes a two cent coin and a twenty cent coin which replaces the quarter. Although such a replacement creates a more efficient system, it is not a viable alternative. The quarter has become a standard unit of account and value. The equipment modification and commercial transaction costs associated with its elimination and subsequent replacement with a twenty cent coin would

Table 3-2

Comparison of Minimum Number of Coins Required at Each Price for Two Sets of Coin Denominations (Method A) 1/

Price In Cents	Coin Denominations: Set 1					Coin Denominations: Set 2					
	1¢	5¢	10¢	25¢	Total	1¢	2¢	5¢	10¢	25¢	Total
1	1				1	1					1
2	2				2		1				1
3	3				3	1	1				2
4	4				4		2				2
5		1			1			1			1
6	1	1			2	1		1			2
7	2	1			3		1	1			2
8	3	1			4	1	1	1			3
9	4	1			5		2	1			3
10			1		1				1		1
11	1		1		2	1			1		2
12	2		1		3		1		1		2
13	3		1		4	1	1		1		3
14	4		1		2		2		1		3
15		1	1		2			1	1		2
16	1	1	1		3	1		1	1		3
17	2	1	1		4		1	1	1		3
18	3	1	1		4	1	1	1	1		4
19	4	1	1		6		2	1	1		4
20			2		2				2		2
21	1		2		3	1			2		3
22	2		2		4		1		2		3
23	3		2		5	1	1		2		4
24	4		2		6		2		2		4
25				1	1					1	1
Cummu-lative	50	10	20	1	81	10	20	10	20	1	61

1/ Although both denomination sets include 50¢ and $1.00 coins, neither of these coins are necessary for transactions in this range -1¢ to 25¢.

Table 3-3

Minimum Number of Coins Required for Transactions at Each Price Between 1¢ and $1 For Ten Sets of Denominations

	Coin Denominations								
	1¢	2¢	5¢	10¢	20¢	25¢	50¢	$1.00	Total
Set Number 1 Coins Required	200	-	40	80	-	50	50	1	421
Set Number 2 Coins Required	40	80	40	80	-	50	50	1	341
Set Number 3 Coins Required	-	193	38	77	-	48	49	1	406 1/
Set Number 4 Coins Required	200	-	40	80	-	150	-	1	471
Set Number 5 Coins Required	40	80	40	80	-	150	1	1	391
Set Number 6 Coins Required	200	-	40	80	-	154	-	-	474
Set Number 7 Coins Required	40	80	40	80	-	154	-	-	394
Set Number 8 Coins Required	40	80	40	40	80	-	50	1	331
Set Number 9 Coins Required	200	-	50	40	80	-	50	1	421
Set Number 10 Coins Required	-	-	40	80	-	50	50	5	225 2/

1/ Transactions not possible at two prices.

2/ Rounding required at 80 prices - all transactions except those ending in 5 or 0.

Table 3-4

Minimum Number of Coins Required to Make Change for The Next Highest Denomination at Each Price Between 1¢ and $1 for Ten Sets of Denominations

	Coin Denominations								
	1¢	2¢	5¢	10¢	20¢	25¢	50¢	$1.00	Total
Set Number 1 Coins Required	196	-	35	65	-	25	0	0	321
Set Number 2 Coins Required	39	77	35	65	-	25	0	0	241
Set Number 3 Coins Required	-	163	35	55	-	23	0	0	276[1/]
Set Number 4 Coins Required	196	-	35	65	-	75	-	0	371[2/]
Set Number 5 Coins Required	39	77	35	65	-	75	-	0	291[2/]
Set Number 6 Coins Required	196	-	35	65	-	75	-	-	371[2/]
Set Number 7 Coins Required	39	77	35	65	-	75	-	-	291[2/]
Set Number 8 Coins Required	39	77	45	30	50	-	0	0	241
Set Number 9 Coins Required	196	-	45	30	50	-	0	0	321
Set Number 10 Coins Required	-	-	40	60	-	25	0	0	130[3/]

[1/] Transactions not possible at ten prices.

[2/] Since this set excludes the half dollar coin, change for $1 is required at prices above 25¢.

[3/] Rounding required at 80 prices - all transactions not ending in -5 or -0.

far exceed those which could be offset by the marginal increase in theoretic efficiency. Alternatively, the present coinage system, plus a two cent coin requires the smallest total number of coins but increases the number of denominations in circulation.

To ascertain the potential reduction in total coin requirements the quantity of coins of each denomination required with the alternative sets was compared to the number required for the present system. For example, cent coins currently represent 75.7 percent of all coins produced. Therefore, an 80.0 percent reduction in cent requirements implies a 60.56 percent reduction in overall coin production. Nickels are currently 6.1 percent of all coins produced, dimes - 9.0 percent, quarters - 7.0 percent, half dollars - 1.6 percent, and dollars - 0.5 percent.

Table 3-5 contains the net percent change in coin requirements resulting with the implementation of each alternative system. The greatest overall reduction, other than through the elimination of the cent altogether, results from addition of a two cent coin to the present system. Theoretically the decrease in coins required would be between 36.6 percent (as calculated by method B) and 41.6 percent (as calculated by method A). However, obstacles to this increase in theoretical efficiency include lack of acceptance of alternative denominations by the public, numismatic demand, and additional inventory requirements.

2.2 Theoretical Versus Actual Requirements

An interesting exercise is the comparison of the theoretical number of coins required for transactions versus actual coin production for the current system. Table 3-6 contains such a comparison. The number of coins of each denomination required using method A is translated into a percentage of all coins by denomination. This calculation highlights the cent dilemma. The actual requirements for cent coins from FY 1970 - FY 1975 was 61 percent greater than the theoretical requirements. Excluding cents from these calculations resulted in the percentages in Table 3-7. Note the contrast between the actual and theoretical percentage of half dollars. In the calculations of exchange efficiency, 22.6 percent of the theoretical coin requirements were half dollars; actual half dollar requirements represented

Table 3-5

Net Change in Coin Requirements Between the Current System and Alternative Sets of Coin Denominations

Set Number	Denomination Set							Number of Coins Required Using Method A	Net Percent Change In Coin Requirements	Number of Coins Required Using Method B	Net Percent Change in Coin Requirements
1	1¢	5¢	10¢	25¢	50¢	$1.00		421	-	321	-
2	1¢	2¢	5¢	10¢	25¢	50¢	$1.00	341	-41.6	241	-36.6
3	2¢	5¢	10¢	25¢	50¢	$1.00		406[1/]	-30.8	276[2/]	-26.8
4	1¢	5¢	10¢	25¢	$1.00			471	+12.4	371	+14.0
5	1¢	2¢	5¢	10¢	25¢	$1.00		391	-34.2	291	-22.6
6	1¢	5¢	10¢	25¢				474	+12.5	371	+14.0
7	1¢	2¢	5¢	10¢	25¢			394	-29.1	291	-27.6
8	1¢	2¢	5¢	10¢	20¢	50¢	$1.00	331	-33.7	241	-31.1
9	1¢	5¢	10¢	20¢	50¢	$1.00		421	+9.0	321	+5.5
10	5¢	10¢	25¢	50¢	$1.00			225	-68.9	130[3/]	-74.8

[1/] Transactions are not facilitated at ten prices.

[2/] Transactions are not facilitated at two prices.

[3/] Rounding required at 80 prices for all transactions except those ending in -5 or -0.

Table 3-6

Comparison of Theoretical With Actual Coin Requirements

	Denomination						
	1¢	5¢	10¢	25¢	50¢	$1.00	Total
Number Required Using Method A	200	40	80	50	50	1	421
Theoretical Percent	47.5	9.5	19.0	11.9	11.9	0.2	100.0
Net Payout, 1970-1975, Actual Percent	76.5	5.5	9.3	5.6	2.3	N.A.	100.0

1/ Average net payout 1970-1975 from: David Stuart, et. al., A Comprehensive Review of U.S. Coinage System Requirements to the Year 1990, Phase I Draft Final Report, p. 2-30.

Table 3-7

Comparison of Theoretical With Actual Coin Requirements
(Excluding Cents)

	Denomination					
	5¢	10¢	25¢	50¢	$1.00	Total
Number Required Using Method A	40	80	50	50	1	221
Theoretical Percent	18.1	36.2	22.6	22.6	0.5	100.0
Net Payout, 1970-1975, Actual Percent	27.8	44.4	21.9	5.8	N.A.	100.0

1/ Average net payout, 1970-1975 from: David Stuart, et. al., A Comprehensive Review of U.S. Coinage System Requirements to the Year 1990, Phase I, Draft Final Report, p. 2-30.

only 5.8 percent of all coins produced (excluding the cent). This is not surprising since the half dollar is cumbersome and a more useful substitute is readily available. Two quarters are equal in weight to one half dollar and are more universally acceptable.

At present, the actual distribution of coin denominations resembles denomination set 6 more than the theoretical distribution of the current system. The half dollar and dollar coins are not functional and account for the reduced commercial efficiency of the existing system. The current denominations are theoretically more efficient (measured by either method) than set 6.

The use of a two cent coin results in an implied increase in the commercial efficiency of the coinage system. This increase is due primarily to the reduction in the number of cents required. In practice however, one cent and two cent coins will not be perfect substitutes. The complexities of dealing with an additional coin denomination may lead to public reluctance to use a two cent coin. The two cent coin may approach an attrition rate similar to that of the one cent coin, particularly as its purchase power erodes with time. Therefore, the introduction of this coin will probably result in an actual increase in efficiency that is 50 to 75 percent of the theoretical increase.

2.3 Ranking of Alternative Denomination Sets

In order to compare the theoretical exchange efficiency of the ten alternative sets of denominations, efficiency indexes were calculated for each set. The minimum number of coins required at each price for each denomination set was divided by the number required for the current set to generate a method A index. Similarly, a method B index was generated for each denomination set. Assuming that transactions of types A and B occur with equal frequency, an average of the two indexes was calculated with which to rank the alternatives.[1/] These alternatives, the index and the rankings are included in Table 3-8. The highest ranking denomination set is number 10--the currently minted denominations excluding the cent. Next is set number 8, in which the quarter is replaced by a twenty cent coin. However, as mentioned above, this increase in theoretic

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[1/] Please note that the resulting ranking would be unaltered with a different weighting of method A vs. method B.

Table 3-8

Ranking of Alternative Denomination Sets by Exchange Efficiency

Set Number	Coin Denominations							Index	Ranking
1	1¢	-	5¢	10¢	25¢	50¢	$1.00	100	7
2	1¢	2¢	5¢	10¢	25¢	50¢	$1.00	78	3
3	-	2¢	5¢	10¢	25¢	50¢	$1.00	91[1/]	4
4	1¢	-	5¢	10¢	25¢	-	$1.00	114	9
5	1¢	2¢	5¢	10¢	25¢	-	$1.00	92	6
6	1¢	-	5¢	10¢	25¢	-	-	114	10
7	1¢	2¢	5¢	10¢	25¢	-	-	92	5
8	1¢	2¢	5¢	10¢	20¢	50¢	$1.00	77	2
9	1¢	-	5¢	10¢	20¢	50¢	$1.00	100	8
10	-	-	5¢	10¢	25¢	50¢	$1.00	46[2/]	1

[1/] Transactions are not facilitated at ten prices.

[2/] Rounding required at 80 prices for all transactions except those ending in -5 or -0.

efficiency is far outweighed by the problems precipitated with the elimination of the quarter. Sets 8 and 9 were therefore excluded from further consideration. The alternative denomination sets exhibiting the greatest efficiency are:

Set Number	Production Efficiency Rating	Denominations						
10	46	-	-	5¢	10¢	25¢	50¢	$1.00
2	78	1¢	2¢	5¢	10¢	25¢	50¢	$1.00
3	91	-	2¢	5¢	10¢	25¢	50¢	$1.00
5	92	1¢	2¢	5¢	10¢	25¢	-	$1.00
7	92	1¢	2¢	5¢	10¢	25¢	-	-
1	100	1¢	-	5¢	10¢	25¢	50¢	$1.00

The most significant decreases in current coin production requirements would result with either the elimination of the cent, or the introduction of a two cent coin. The other alternative sets of denominations do not allow sufficient production economies to warrant the transition costs. The focus is therefore on these two alternative sets of coin denominations.

These indexes and rankings fail to highlight the potential costs of rounding. To calculate an estimate of this rounding cost, the methodology illustrated in Table 3-9 was used. As a worst case, assuming that all transactions requiring rounding were rounded up, a rounding loss averaging two cents per transaction results when the nickel is the lowest denomination. Conversely if transactions were rounded up and down with equal frequency, no loss or gain would be incurred.

If the merchant gained an average of 0.5¢ per transaction, the loss to the public would be in excess of $1 billion, based on cash transactions data as reported in Table 3-9. This loss represents only 0.51 percent of the total value of cash transactions. However, it comprises a much greater percent of lower valued transactions: 0.5¢ represents an increase ranging from 0.5 percent on a $1 item to two percent on a 25¢ item.

Table 3-9

Estimated Public Loss Incurred With Rounding

Average Value of Transaction 1/	Number of Cash Transactions of Each Size (Billions) 1/	Total Value of Transactions (Billions)	Average Rounding Loss Per Transaction (Percent) 2/	Rounding Loss (Million $)
$0.25	162	$40.5	2.00	$810.0
$3.50	43	$150.5	0.14	$210.7
$10.00	11	$11.0	0.05	$ 5.5
TOTAL	196	$202.0	0.51	$1,026.2

1/ SOURCE: The Consequences of Electronic Funds Transfer, Table 4-7, p. 57. National Science Foundation. Research Applied to National Needs. NSF-0844, June, 1975.

2/ Assuming 0.5¢ per transaction rounding gain to merchant.

The negative impacts on consumers from rounding of transactions would be greatest if the cent was eliminated with no advance notice and was immediately withdrawn from circulation. However, withdrawal of the complete stock of more than 45 billion cents in circulation would require several years. Localized shortages would lead to some immediate rounding, but in general there would be sufficient time for an orderly transition to a no-penny economy. Adjustments through product pricing, product packaging, sales tax administration, and other market place adjustments will reduce the burden on consumers of transition to a no-penny economy.

In summary, two alternative sets of coin denominations provide sufficient production economies to warrant fuller consideration in light of the transition costs that might be incurred with their implementation. These two sets are characterized by the elimination of the cent and the introduction of a two cent coin. These two sets of coin denominations include both the half dollar and one dollar coins. As indicated in the earlier discussion of the theoretic versus the actual efficiency of the current coinage system, the half dollar and one dollar coin do not readily circulate. One alternative is to discontinue production of both denominations altogether. Although not measurable by "exchange" efficiency, the most obvious manner in which to improve the circulation of these two denominations is to reduce their size. However, both coins could not be reduced in size substantially enough to enhance their circulation and still allow sufficient discrimination between the quarter, the half dollar and the dollar. It is therefore recommended that either the one dollar coin be reduced to a more efficient size and elimination of the half dollar considered, or that both denominations be eliminated.

3.0 ACCEPTABILITY OF ALTERNATIVE CHANGES TO COIN USERS

3.1 Introduction

Several alternative systems of coin denominations would lead to increased exchange efficiency. Characterizing these alternatives as discussed above are various changes in the present system including the elimination of the cent, the introduction of a two cent coin, and/or the

introduction of a smaller one dollar coin. However, the increased exchange efficiency would not translate into an increase in commercial efficiency unless the alternative system of coin denominations circulated freely. Circulation, admittedly dependent on the availability of the coins to the public, is for the most part a function of ready acceptance of the coins by major groups of coin users. As discussed above, lack of acceptance of the current half dollar and dollar coins results in a real coinage system that is less efficient than theory would imply. Consequently, in this study an effort was made to ascertain the extent to which these selected alternatives would be accepted by coin users.

While nearly all individuals and business firms use coins to some extent in conducting economic transactions, the organizations that would incur the greatest impact from changes in the coinage system are those which employ automatic equipment for receiving, processing, and distributing coinage. Automatic coinage processing systems lack flexibility and can accommodate changes less easily than manual systems. Thus, the organizations which constituted the primary subjects of this effort were those businesses which conduct large volumes of low price cash transactions in few locations or in a number of relatively homogeneous facilities dispersed across a wider geographic area. Organizations which process large volumes of coinage at a single location are most likely to employ automatic coin processing equipment, and organizations whose basic facilities are replicated in a number of sites, generally use similar cash registers and coin changers throughout their corporate systems.

The significance of the impact of a change is perhaps as varied as the sectors that are involved. These sectors are defined here to include retail merchandising firms, commercial banks, automatic merchandising firms, coin processing equipment manufacturers and tax administrators. The variations in impact across these groups stem from the differing manners in which the business operations of each individual group are related to coin use. For example, the basis for coin-related operations in retail firms and commercial banks are person-to-person transactions, while coin operations for vending companies are based on person to machine transactions. State Departments of Revenue, included here as

tax administrators, are concerned with the efficient collection of sales taxes. Many states now employ a sales tax which could be more cumbersome to administer and perplexing to the consumer without the cent coin. Not surprisingly, this target group of coin users is overwhelmingly opposed to the elimination of the cent. Although a retail firm manager might recognize the lack of circulation of the dollar coin as currently minted, he might well prefer the retention of an inefficient coin to the introduction of an alternative that would require accomodation. Alternatively, an automatic merchandiser might welcome a convenient dollar coin as giving greater scope to the market for vended products.

As mentioned earlier, market research was conducted on the preferences of selected target groups of coin users with respect to candidate changes in the U.S. coinage system. This market research was accomplished through the use of questionnaires mailed to members of these target groups. An individual questionnaire was designed for each of the six target groups, and representatives of each group assisted in the final design of these questionnaires.

A list of all public and private organizations that handle coins and a measure of the extent of their use would have comprised the ideal sample for this study. However, such a list does not exist and would have been costly to construct. Alternatively, samples were selected in other manners. For the sample of retail firms, businesses whose quantity and type of commercial transactions warranted the use of automatic coin processing equipment were identified by Standard Industrial Classification (SIC) code. A sample of 206 of these firms was selected from the Dun and Bradstreet Million Dollar Directory to include the 35 leading general merchandising chains in 1973 and 171 additional firms whose net worth was greater than $1,000,000 in 1974. (Survey respondents accounted for 28 percent of nondurable retail sales in 1976.) For the sample of commercial banks, the leading 100 banks, measured in terms of total deposits, were initially selected; 105 other banks were then selected from Polk's Bank Directory for 1975. (Bank survey respondents accounted for 60 percent of total bank deposits in 1974.) The National Automatic Merchandising Association Members Directory, 1975 was the source for data on automatic merchandising service companies. Fifty-nine companies

were selected from the list of member companies. A list of 50 local and suburban transit companies provided by the American Public Transit Association constituted the sample for the transit industry. A list of the tax administrators in each of the states was provided by the National Association of Tax Administrators.

The administration of the survey included a mailing of the appropriate questionnaire and cover letter to each of the sampled firms in the six target groups of coin users. Responses to the questionnaires were recorded and are summarized.[1/] Additional information regarding the survey is included in Appendix B.

3.2 Preferred Coin Denominations

To determine if representatives in the nondurable goods retail sales and the commercial banking industries perceived any need for change in the current mix of coin denominations, respondents in these industries were asked whether any coins currently minted and circulated should be discontinued because they are no longer useful for commercial transactions. As can be seen in Exhibit 3-1, more than half of each group preferred the discontinuance of some coin denomination(s); including almost two-thirds of all responding banks. Exhibit 3-2 presents the coins most often chosen to be discontinued and the frequency of their choice. The present one dollar coin was most frequently chosen by both banks and retail firms. Almost all (93.6 percent) of the respondents in the banking industry that indicated a preference for discontinuing some denomination chose the present one dollar coin, with a smaller percentage of the retail firms choosing similarly. The other coin that was indicated for discontinuance was the present half dollar coin, with 21.6 percent of the responding banks and 27.2 percent of the responding retail firms indicating a preference for its discontinuance because it is no longer useful for commercial transactions.

Respondents in each group (except tax administrators) were asked to rank several combinations of coin denominations in terms of their potential value for transactions in 1980 and 1990. The first choice of each respondent was recorded. Table 3-10 presents a summary of the responses.

[1/] M. Anne Hill, Analysis of User Responses to Candidate Changes in the U.S. Coinage System. Research Triangle Institute RM-26U-1133-5, May, 1976.

Exhibit 3-1

SHOULD ANY COINS CURRENTLY MINTED AND CIRCULATED BE DISCONTINUED?

RESPONSE BY GROUP

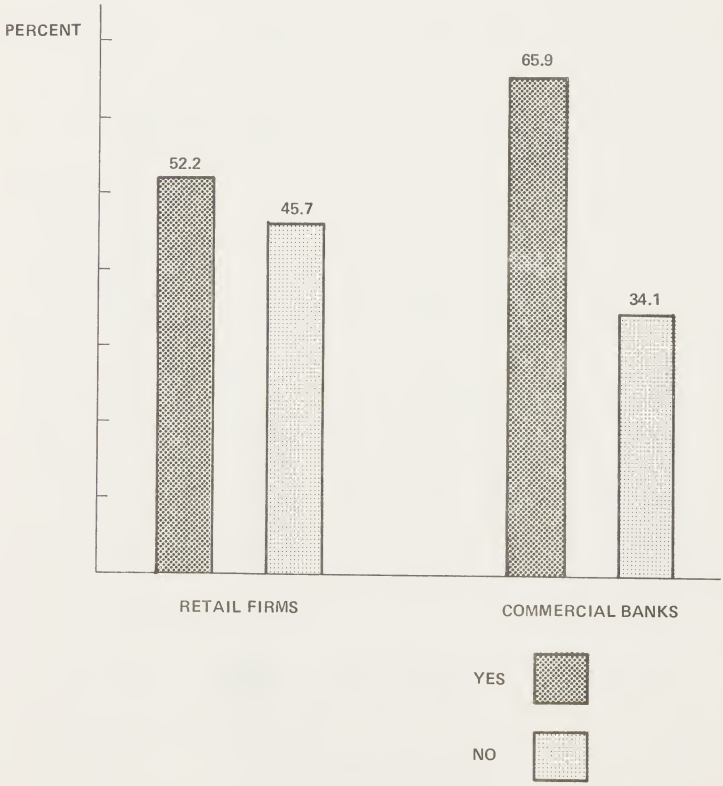


Exhibit 3-2

WHICH CURRENTLY MINTED AND CIRCULATED COINS SHOULD BE DISCONTINUED?

RESPONSE BY GROUP

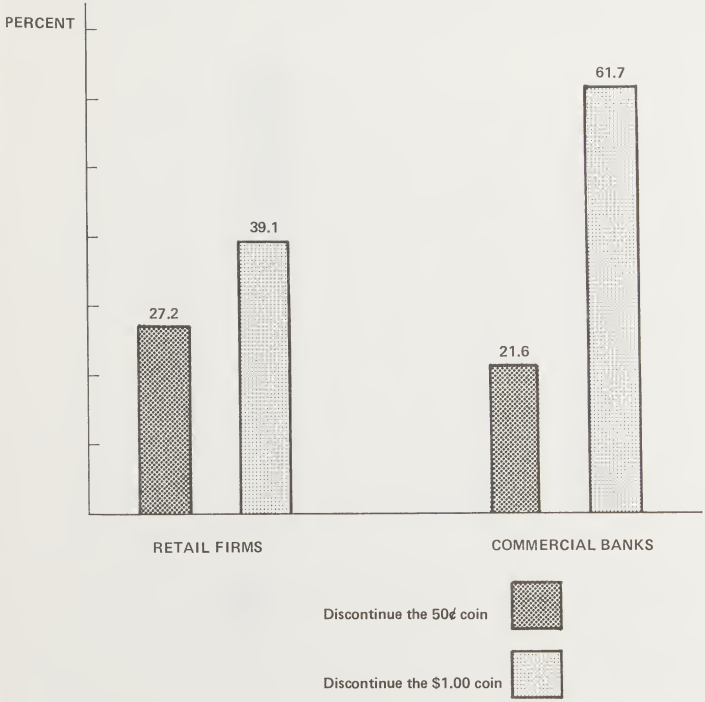


Table 3-10

Preferred Mix of Coin Denominations for 1980 and 1990 by Group

MIX OF DENOMINATIONS

RETAIL FIRMS					
For 1980					
47.3% Prefer	1¢-5¢	10¢	25¢	50¢	$1.00 -
10.3% Prefer	1¢ 2¢ 5¢	10¢	25¢	50¢	$1.00 -
42.4% Prefer Other Combinations					
For 1990					
29.3% Prefer	1¢-5¢	10¢	25¢	50¢	$1.00 -
9.2% Prefer	1¢-5¢	10¢	25¢	50¢	$1.00 $2.00
61.5% Prefer Other Combinations					
COMMERCIAL BANKS					
For 1980					
56.3% Prefer	1¢-5¢	10¢	25¢	50¢	$1.00 -
43.7% Prefer Other Combinations					
For 1990					
33.5% Prefer	1¢-5¢	10¢	25¢	50¢	$1.00 -
11.4% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
55.1% Prefer Other Combinations					
AUTOMATIC MERCHANDISING FIRMS					
For 1980					
53.7% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
46.3% Prefer Other Combinations					
For 1990					
38.9% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
25.9% Prefer	--5¢	10¢	25¢	50¢	$1.00 $2.00
35.2% Prefer Other Combinations					
MANUFACTURERS OF COIN EQUIPMENT					
For 1980					
31.3% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
68.7% Prefer Other Combinations					
For 1990					
18.8% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
12.5% Prefer	--5¢	10¢	25¢	50¢	$1.00 $5.00
68.7% Prefer Other Combinations					
TRANSPORTATION SYSTEMS OPERATORS					
For 1980					
60.0% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
40.0% Prefer Other Combinations					
For 1990					
40.0% Prefer	--5¢	10¢	25¢	50¢	$1.00 -
10.0% Prefer	--5¢	10¢	25¢	50¢	$1.00 $5.00
50.0% Prefer Other Combinations					

The most frequent preference of both retail firms and commercial banks for 1980 was the present mix of coin denominations. Fewer respondents chose this mix of denominations for 1990. Respondents (9.2 percent) in the retail industry chose a mix of denominations including the present six coins as well as a two dollar coin. Several of the responding commercial banks (11.4 percent) chose a mix of denominations equivalent to the present system excluding the cent for 1990. The preferred combination of coin denominations for the remaining groups of coin users excluded the cent for both 1980 and 1990.

Table 3-11 contains the frequencies of preferences for selected combinations of coin denominations by group. The first group includes retail firms and commercial banks--the group of respondents whose coin-related operations involve person to person transactions. The second group includes respondents whose coin-related operations are based on person to machine transactions. The combination of coin denominations most frequently chosen by the first group was the present system, selected by 31.3 percent of the respondents. The second most frequent selection was the combination equivalent to the current system excluding the cent (denomination set 10, as discussed above). This combination was that most frequently chosen by the second group, selected by 35.6 percent of all respondents. Another combination of denominations favored by 20.0 percent of the respondents in the second group was this latter set with the addition of a $5.00 coin.

3.3 The Elimination of the Cent

Three questions in the survey were constructed to provide data on the attitudes of each target group toward elimination of the cent. They were asked whether any coins should be discontinued because they are no longer useful for commercial transactions; asked to rank combinations of coin denominations according to their value for commercial transactions in 1980 and 1990; and asked directly their opinion of eliminating the cent.

When asked whether any denomination should be eliminated because it was no longer useful for commercial transactions, only 2.7 percent of the retail businesses and 6.6 percent of the commercial banks identified the cent as no longer useful.

Table 3-11

Combinations of Coin Denominations Preferred for 1990 by Group

Denominations								Percent of Each Group Preferring Combination	
								Group I[1/]	Group II[2/]
1¢	2¢	5¢	10¢	25¢	50¢	$1.00	-	6.8	2.2
-	2¢	5¢	10¢	25¢	50¢	$1.00	-	7.7	-
-	-	5¢	10¢	25¢	50¢	$1.00	-	10.5	35.6
1¢	-	5¢	10¢	25¢	50¢	$1.00	-	31.3	6.7
1¢	-	5¢	10¢	25¢	50¢	$1.00	$2.00	7.4	5.6
-	-	5¢	10¢	25¢	-	$1.00	$2.00	6.6	-
-	-	5¢	10¢	25¢	-	$1.00	$5.00	-	20.0
1¢	-	5¢	10¢	25¢	-	-	-	2.0	1.1
1¢	-	5¢	10¢	25¢	50¢	-	-	7.4	2.2
1¢	-	5¢	10¢	25¢	-	$1.00	$2.00	1.1	1.1
All Other Combinations								12.9	10.0
Not Applicable or Nonresponse								6.3	15.6
TOTAL								100.0	100.0

[1/] Includes Retail Firms and Commercial Banks.

[2/] Includes Automatic Merchandising Firms, Manufacturers of Coin Equipment, and Transportation Systems Operators.

With respect to the combinations of coin denominations believed to have the most potential value for commercial transactions in 1980, 11.4 percent of the retail businesses, 9.5 percent of the commercial banks, and 60.2 percent of the automatic merchandising firms selected combinations of denominations that excluded the cent. For 1990, 26.5 percent of the retail businesses, 28.2 percent of the commercial banks, and 64.8 percent of the automatic merchandising firms selected combinations which excluded the cent. Thus, even for 1990 a majority of the industries utilizing person to person coin transactions favored combinations of coin denominations which included the cent, while industries relying upon person to machine transactions favored deletion of the cent.

The automatic merchandising firms were asked what percent of their vending machines accepted particular denominations of coins. Two percent of the responding companies indicated that between 26 and 50 percent of their machines accepted the cent coin. None of the other respondents indicated any acceptance of the cent coin in their machines. In addition, none of the respondents indicated that any of their machines paid out cent coins as change for transactions. These responses confirmed the present limited utility of the cent coin for automatic merchandising.

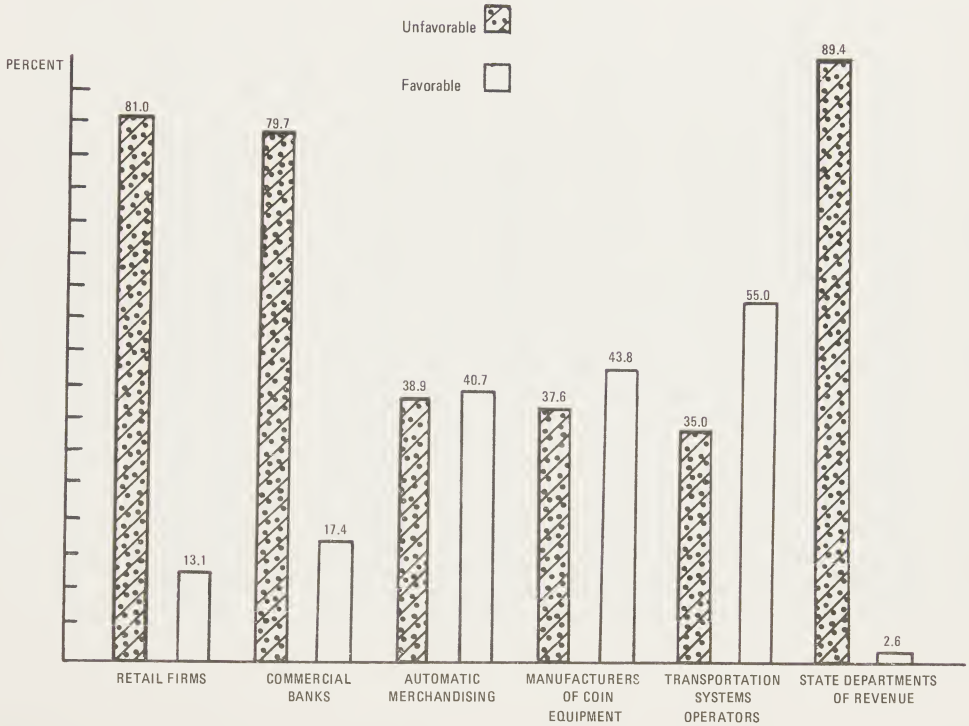
Finally, the target groups were asked outright about their attitudes toward eliminating the cent. Exhibit 3-3 summarizes the responses. Approximately 90 percent of the State Departments of Revenue and 80 percent of the retail firms and commercial banks opposed elimination of the cent. Those industries relying on person to machine transactions responded more favorably toward eliminating the cent; yet less than half were in favor.

Respondents commented, citing various reasons for their opinion on eliminating the cent. Many focused on the potential problems that would be encountered with merchandise pricing and the calculation of sales tax. Several retail firms commented:

> "Because of the constant inflation in our present economy the coinage requirement less than 5¢ are more costly to use and account for than if they had never existed. Our only drawback to the total elimination of coinage less than 5¢ would be the state or local city sales tax which hamper the thought of the discontinuance of the small coin."

Exhibit 3-3

RESPONSE TO THE ELIMINATION OF THE PENNY
BY GROUP



"Present customer service and customer habit would have to be changed drastically. . . also, local sales tax adding practice would present significant point of sale problems."

"We would have to develop a method of reimbursement for items currently requiring a penny in settlement. Example, use of a credit slip. Also, try and reduce odd cent pricing to reduce penny settlements."

"Retail pricing structure would have to be changed: merchandise reticketed; computer reprogrammed, clerical personnel retrained. Total cost would be unreasonable in light of benefits gained."

The potential inflationary effect was also a concern:

"Probably stimulate further inflation; change too abrupt; change to 2¢ more logical."

Commercial bankers responded similarly:

"Discontinuance would be inflationary. Goods would be automatically priced upwards. Same would apply to state and local sales taxes. If sales taxes were not raised, state and local governments would have to issue tokens in place of pennies."

"Pennies are operationally difficult to process from time, volume, and storage viewpoints; however, the discontinuance of the penny would result in an unfavorable consumer reaction."

Respondents in automatic merchandising were marginally in favor of eliminating the cent. Several automatic merchandising firms commented:

"We do not use pennies at all at this time - our experience with penny changers is very negative at this time."

"Not valuable in vending. Recent penny shortage showed great utility of penny."

"Although we could use 5¢ price structure, meal and sales tax would make this impractical."

Several manufacturers of coin equipment responded:

"Current nickel is equal to 1933 penny. In our business penny increases are usually insufficient to profit operator or client."

"Would be extremely unwise, destroys our system. Like saying that we can do without odd numbers except 5."

The State Departments of Revenue were overwhelmingly unfavorable to eliminating the cent. One respondent commented that the sales tax law in his state

> ". . .requires a retailer who over-collects sales tax to refund the over-collection to the customer upon the demand of the customer. The elimination of pennies would in effect force retailers to over-collect the tax and upon demand to refund the tax by check which would be expensive to the retailer and chaotic to the administration of equitable sales tax. It is obviously impractical to attempt to collect a graduated sales tax when a nickel is the smallest coin in circulation. When sales taxes were initially imposed during the 1930's, some states used tokens rather than coins to permit the accurate collection of tax in amounts of less than 1 cent. This became impractical and was discontinued. The elimination of the penny could result in states again turning to tokens -- the cost of which would far exceed their value as sales tax payments media."

In summary, those businesses relying on person-to-person cash transactions predominantly expressed that the cent is a necessary denomination today, and will continue to be a necessary unit for commercial transactions in 1980 and 1990. Only those businesses which rely on person-to-machine transactions expressed any significant willingness to see the cent eliminated by 1990. The reason for the more general acceptance by the automatic merchandising firms is that coin validators as structured do not accept cents to complete transactions but automatically reject those cents inserted. Thus, elimination of the cent would have little effect on automatic merchandising transactions and would eliminate a potential source of spurious vends and machine jams.

3.4 The Introduction of a Two Cent Coin

Four questions in the survey of target groups were constructed to provide data on the attitudes of each of the target groups toward the introduction of a two cent coin. They were asked whether any additional coins should be introduced into circulation because they would be useful for commercial transactions; asked to rank combinations of coin denominations according to their value for commercial transactions in 1980 and 1990; asked directly their opinion of the introduction of a two cent coin; and asked whether if introduced, the two cent coin should be an additional denomination or replace an existing denomination.

When asked whether any additional denomination should be introduced because it would be useful for commercial transactions, 10.3 percent of the retail businesses and 7.8 percent of the commercial banks identified the two cent coin as a needed additional denomination.

With respect to the combinations of coin denominations believed to have the most potential value for commercial transactions in 1980, 16.4 percent of the retail businesses, 13.8 percent of the commercial banks, and 7.4 percent of the automatic merchandising firms selected combinations of denominations that included a two cent coin. For 1990, 15.2 percent of the retail businesses, 17.8 percent of the commercial banks, and 1.9 percent of the automatic merchandising firms selected combinations that included a two cent coin. Thus, even for 1990 very little support was given for a two cent coin.

The target groups were asked outright about their attitudes toward the introduction of a two cent coin. Exhibit 3-4 summarizes these responses. The State Departments of Revenue were the only group expressing more favor than disfavor of the introduction of a two cent coin but the respondents favoring introduction did not constitute a majority.

The other target groups were overwhelmingly unfavorable to the introduction of such a coin. When asked whether the two cent coin should be an additional denomination or replace an existing denomination, most respondents in all target groups except the transportation systems operators preferred that it be an additional denomination. These responses are summarized in Exhibit 3-5.

The comments by retail firms in response to the introduction of an additional coin denomination reflected primarily the problems that would be encountered in bookkeeping, clerical work, or making change:

> "It is easier to use more pennies than to keep up with additional denominations."

> "An additional denomination would have to be considered in making change, thus creating a possibility for errors."

> "The last thing we need is another coin to cause confusion and handling problems at store level."

Exhibit 3-4

RESPONSE TO THE INTRODUCTION OF A TWO-CENT COIN BY GROUP

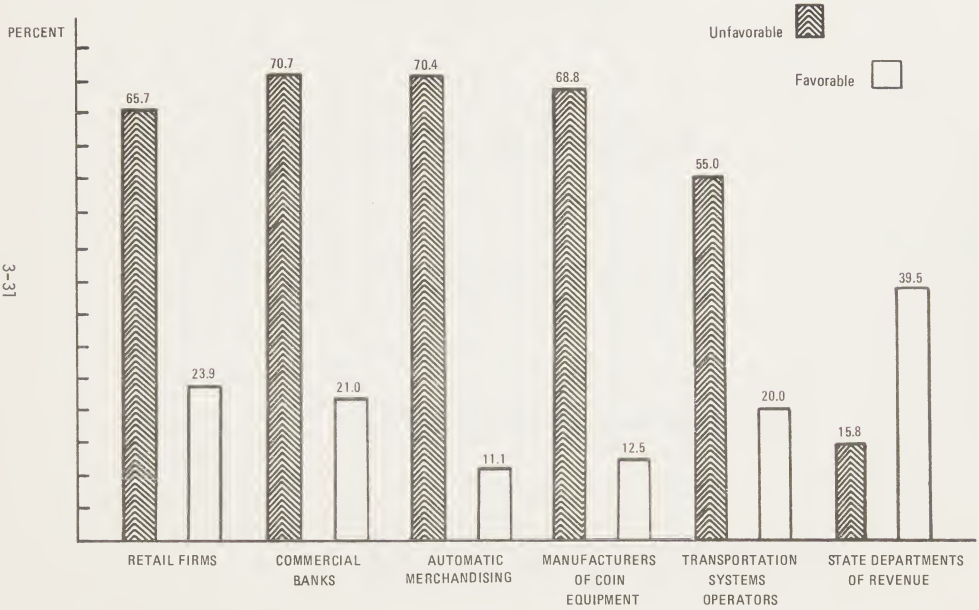
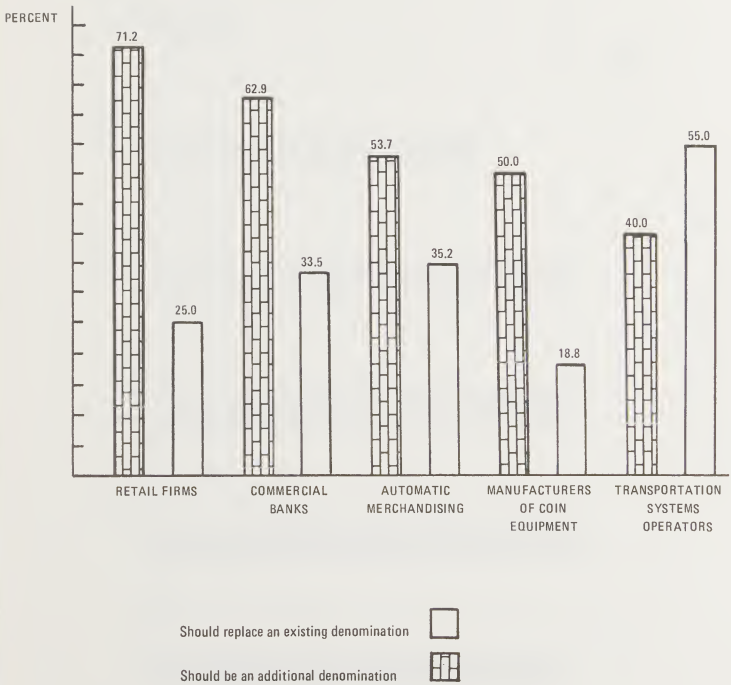


Exhibit 3-5

SHOULD THE TWO-CENT COIN REPLACE AN EXISTING DENOMINATION OR SHOULD IT BE AN ADDITIONAL DENOMINATION? RESPONSES BY GROUP



"The cost of introducing new denominations far outweigh the benefits to be received."

The reasons for disfavor of the introduction of the two cent coin given by the banking industry were similar to those of the retail firms:

"Extremely costly - required purchase of additional coin handling equipment - possibly obsoleting all present equipment to handle this new coin plus additional inventory storage area in vaults. Also contrary to customers policy of keeping their coin requirements as simple as possible."

"The need for pennies would probably not diminish to any great degree. The effect would be an additional burden on the coin handling system, substantial equipment costs with questionable benefits."

One automatic merchandising firm commented:

"Not valuable in vending. See no need to complicate coinage. Penny will eventually phase out, but 2¢ is just adding cost and confusion."

Manufacturers of coin equipment expressed their disfavor with the introduction of a two cent coin:

"Can see no need whatsoever for 2¢ coin."

"Believe cost and disadvantages would outweigh any advantages."

"We believe that the complexities of handling 2¢ coins (acceptance or rejection) outweigh any potential utilization."

"Sorting machines could not be easily changed to register the new values."

Responding tax administrators were favorable to the introduction of a two cent coin. One respondent commented:

"The co-circulation of 2¢ coins with pennies would have no effect on sales tax administration unless the penny became a collector's item and was withdrawn from circulation for the intrinsic value of the metal in the penny. This has happened with silver coins in the United States and other countries. The penny is a necessary unit of exchange to permit the accurate payment of sales tax or sales tax reimbursement."

In summary, the only respondents indicating any acceptance of a two cent coin are State Departments of Revenue, where a two cent coin is seen as a viable alternative to the elimination of the cent. However, the favorable respondents in that group did not constitute a majority. There is, in short, little supportive reaction by coinage users to the introduction of a two cent coin. A two cent coin would have little effect on the markets of automatic merchandisers: ideally the coin would be automatically rejected as the cent coin is today. From the standpoint of retail firms and commercial banks, it represents added processing and storage cost.

3.5 The Half Dollar and the One Dollar Coins

The actual utilization of the half dollar coin for commercial transactions falls very short of theoretical expectations, and commercial use of the one dollar coin is virtually nonexistent. Thus, several questions in the survey were designed to obtain information from the target user groups about their preferences and attitudes toward the half dollar and one dollar coins.

When asked whether any denomination should be eliminated from circulation because it was no longer useful for commercial transactions, 61.7 percent of the commercial banks and 39.1 percent of the retail firms responding identified the present one dollar coin as a candidate for elimination. Similarly, 21.6 percent of the commercial banks and 27.2 percent of the retail firms identified the half dollar coin as a candidate for elimination. (Refer to Exhibit 3-2.)

With respect to the combinations of coin denominations believed to have the most potential value for commercial transactions in 1980, 19.8 percent of the commercial banks, and 11.4 percent of the retail business selected combinations of denominations that excluded the dollar coin, while 9.5 percent of the commercial banks and 8.7 percent of the retail firms selected combinations excluding the half dollar coin. For 1990, 15.6 percent of the commercial banks and 10.9 percent of the retail businesses selected combinations excluding the dollar; 13.6 percent of retail firms and 10.8 percent of the commercial banks selected combinations excluding the half dollar. However, the responses may be biased since all

of the combinations listed in the questionnaire included the dollar coin, and all but one combination included the half dollar. Those respondents excluding these denominations were registering specific objections to the denominations by specifically defining a preferred combination.

When asked to describe their preferences for the configuration of a one dollar coin which would be useful, 57.8 percent of the responding retail firms and 43.7 percent of the banks selected the present diameter as most preferred for the dollar coin. Twenty-eight and 29 percent of the retail firms and the banks respectively preferred a diameter between that of the present quarter and half dollar.

Overall, the responses of the retail firms and the commercial banks concerning their preferences for the half dollar and one dollar coins contained some inconsistencies due partially to the deliberate structure of the questionnaire but primarily to the ambivalent attitudes towards the half dollar and dollar. For example, several of the respondents who said the present dollar coin was not useful and should be eliminated also replied that its present size is best.

Representative comments from the retail business firms and the commercial banks include:

> "We feel the $1.00 coin is the least commonly used denomination and should be phased out of circulation."

> "Discontinue - of no value - heavier than bill and could be mixed up with half dollar. Easier to carry bill than coin."

> "I believe the introduction of (smaller size) $1 and $2 coins could be very beneficial from the economic standpoint of government. 'Size' is the most important consideration, because it dictates convenience to the user."

> "Many customers now refuse the half dollar coin, and it is difficult to imagine a more acceptable one dollar coin."

> "A one dollar coin that would circulate freely would reduce the need for one dollar bills if not eliminate them. The major advantage would be the coin life expectancy of twenty-five years compared to the bill's life of one and a half years."

> "If the one dollar coin were configured to a more popular size it should become attractive for vending machines and exact fare purposes for transportation companies."

The automatic merchandising firms and the manufacturers of coin processing equipment were more definitive in their opinions about the value of the half dollar and dollar coins. As an indication of current acceptance, the vending industry respondents indicated that less than 20 percent and 9 percent of the companies had any machines which accepted half dollar and dollar coins respectively.

With respect to future utility of the denominations, none of the firms selected a combination of denominations for 1980 or 1990 which excluded the dollar, and less than six percent excluded the half dollar. In fact, 13 percent of the respondents for 1980 and 35 percent for 1990 selected combinations which included the two dollar coin.

When asked to describe their preference for the configuration of the one dollar coin, 65 percent of the vending company respondents selected a size that was smaller than the present half dollar. Similarly, over half the manufacturers of coin processing equipment that responded, indicated a preference for a smaller dollar coin.

Approximately one-third of the vending companies considered the present sized dollar coin to be the most desirable for commercial transactions. They did not want a smaller dollar coin for vending, because they would have to make capital expenditures for equipment to accept it. Dollar coin accepting machines would be in direct competition with present equipment in some cases. Therefore, capital expenditures and competition could both be avoided if the coinage status quo is maintained.

The rationale for the greater preference for a conveniently sized dollar coin by vending companies is evident. The respondents estimated that the vend price of their average product increased 25 to 50 percent between 1970 and 1975. In addition, the market potential for vending is generally limited to products priced under a dollar. Introduction of a freely circulating dollar coin would significantly expand the market potential for the automatic merchandising industry.

A sample of the comments by vending company respondents and manufacturers of coin processing equipment includes:

> ". . .With prices constantly increasing, a usable one dollar coin could give more flexibility. Might increase sales if machines were geared to accept one dollar coin because a separate dollar bill changer might not be required. Less coins would be required overall."

"Usable one dollar coin would appear to have practical application in vending industry."

"It would give the vending industry the means by which they could keep up with inflationary trends in pricing of cigarette and cold food items. Would speed up vend cycle time by customers inserting one coin and receiving change."

"Would open vending equipment to additional products and price increases in excess of $1.00 without additional equipment to handle paper money."

"Could eliminate need for dollar changers and be more convenient for customers."

3.6 Concluding Observations

The candidate alternatives to the present U.S. coinage system will have varying impacts across the target groups of coin users. These impacts are a function of the current or potential utility or disutility of the alternative in question to each individual group.

In terms of exchange efficiency, the present set of coin denominations, excluding the cent coin, generates the lowest total coin requirements and reduces the number of denominations required. However, elimination of the cent is generally unacceptable to most user groups since the cent coin serves primarily as a unit of account, and those groups that utilize this unit of account are particularly opposed to its elimination. The state sales tax administrators are almost unanimously opposed, because it would require procedural, structural, and legislative changes in sales taxes and their administration. Retail businesses are opposed because it would require rounding the values of transactions and/or restructuring of accounting systems, product pricing, and packaging practices.

Although handling, processing, and storage of cent coins is a costly nuisance to commercial banks, they too are opposed to its elimination due to the accounting and procedural changes that would be necessitated.

The firms in the automatic merchandising industry were the only surveyed group not strongly opposed to elimination of the cent. The cent is not accepted in most vending machines but viewed as a slug, except in the vending of a few products such as penny gum.

Finally, the largest single group of coin users, the consumers, was not surveyed. Their composite attitude toward elimination of the cent is not known. The cent attrition rate provides evidence that an increasing number of consumers view the cent as a nuisance coin. That is, the effort necessary to return the cents in their possession to circulation outweighs the commercial value gained in transactions. However, the overall attitudes of consumers toward eliminating the cent will likely depend upon the actual or perceived adjustments of product prices and the policies that are implemented for rounding transactions.

The second most efficient set of coin denominations in terms of exchange efficiency is the present mix of denominations with an additional two cent coin. This set theoretically requires a greater number of coins and two more denominations than the most efficient combination. However, to its advantage, this combination theoretically requires only 78 percent of the total coins necessary with the present system; and all transactions can be facilitated without rounding. The implementation of this system would reduce the number of cent coins required, and would provide a less abrupt transition in the event of the elimination of the cent.

However, approximately 70 percent of the retail businesses, commercial banks, and automatic merchandising service firms surveyed opposed the introduction of a two cent coin. Their objections were based on the additional complexity of the system, and the additional costs associated with processing, handling, and storing an additional denomination. Only 16 percent of the state sales tax administrators expressed disfavor with a two cent coin, since it would not adversely affect the administration or collection of sales taxes.

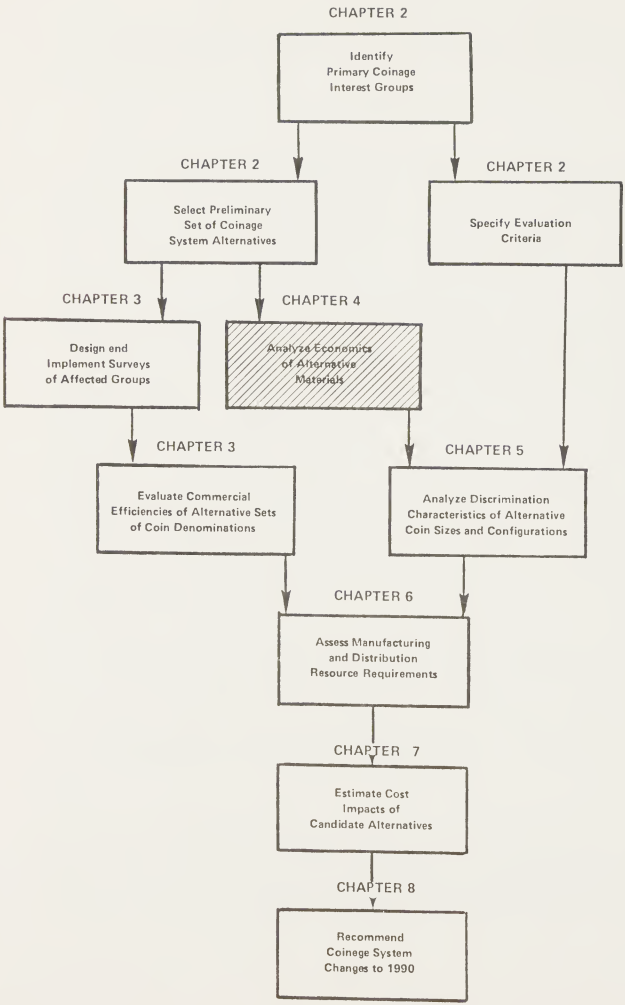
Whether the half dollar and/or the one dollar coins should be eliminated or changed in size is a distinctly different issue than the situation of the lower coin denominations. Essentially, the half dollar and dollar coins are not used in commercial transactions because they have readily available, superior substitutes - two quarters for the half dollar and a dollar note for the dollar coin.

The responses of the target groups with respect to the half dollar and dollar coins were somewhat contradictory. Approximately half the responding retail firms and commercial banks acknowledged that the present

dollar was not useful for commercial transactions and should be eliminated, yet their selection of ideal mixes of denominations for 1980 and 1990 demonstrated the potential utility of higher denominations for coins in the future. Paradoxically when these respondents were asked to describe their preferred configuration for the one dollar coin, many selected the current configuration. They exhibited reluctance to change the configuration to a more convenient size that could appreciate greater acceptance and wider circulation.

Clearly the commercial advantages of a conveniently-sized one dollar coin would accrue to the automatic merchandising industry. Should such a coin gain widespread public acceptance, those firms engaged in coin handling, processing, and storage would have additional costs to accommodate the coin without fully benefitting from its advantages. This imbalance among the industries, relative to potential benefits received versus potential costs incurred, explains the differences in attitudes toward the alternatives for the one dollar coin.

In general, the retail sales, banking, and automatic merchandising industry respondents expressed their desire to maintain the status quo with respect to the U.S. coinage system. The advantages of changes in the denominations, size, or material compositions of U.S. coins were perceived to be outweighed by the inconvenience or expense of accomodating the candidate changes. While the long-term economies and associated commercial advantages of the candidate alternatives were not clearly recognized by the business firms, the immediate cost and administrative impacts were obvious. Thus, even with its inefficiencies and shortcomings recognized, the businesses surveyed preferred the existing U.S. coinage mix to the candidate alternatives.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design end Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 4

Evaluation of Candidate Materials for Coinage Alternatives

1.0 INTRODUCTION

If a two cent coin is added to the current mix of U.S. coin denominations, its material must be selected. If the present denominations are to be maintained, less costly material must be chosen for the one cent coin. Similarly, a change the material composition of the one dollar coin in conjunction with a change in size may be desirable. This chapter summarizes the important economic and technical considerations relevant to the selection of a material for each of these alternatives.

This selection must be sensitive to the manner in which the candidate materials satisfy relevant criteria; including seigniorage protection (or the difference between the face value of the coin and its cost to manufacture), durability, eddy current discrimination, and aesthetic appearance. Seigniorage protection obviously depends upon the economic characteristics of the material, while the physical properties of the material itself would be pertinent to the remaining criteria.

The following materials, alloys, and cladding combinations represent those which were preliminary candidates but were subsequently rejected for the stated reasons[1/]:

Chromium is not available in the strip form necessary for Mint coin production and little is known about its formability;

Tin is too soft, and can pulverize at extremely low temperatures;

Titanium PM is incompatible with current Mint forming technology, and economic data were not available;

[1/] For a more complete and detailed analysis of the materials selection see: Stephen A. Johnston and Hans Stadelmaier, Evaluation of Candidate Materials, Alloys and Cladding Combinations for United State Coinage, Research Triangle Institute, January 1976. RM-26U-1133-1.

Copper-Aluminum and Copper-Tin alloys have no advantages over copper-zinc alloys and are less coinable;

Copper-Tin-Zinc like chromium is not fabricated as strip;

Copper-Aluminum-Nickel is malleable at high temperatures only and is consequently less formable than cupronickel;

Copper-Zinc-Nickel alloys are best suited as cladding materials although they are less formable than cupronickel;

Aluminum-Nickel alloys are not common and would be difficult to coin;

Stainless Steels are also difficult to coin;

Nickel Clad on Steel is magnetic and therefore incompatible with present coin validation technology.

Several materials were considered to be viable candidates as alternatives to the present cent coin or as a possible two cent coin. These materials included: the range of copper (cu)-zinc(zn) alloys from 95 cu-5 zn (penny bronze) to 70 cu-30 zn (cartridge brass), the copper-zinc alloys clad on a steel core, and aluminum.

Candidate materials for the one dollar coin include: the present sandwich material of a 75 cu-25 ni allou clad on a copper core, brass (70 cu-30 zn), cupronickel (75 cu-25 ni), cupronickel clad on nickel, and pure nickel.

The analysis in this chapter is divided into two sections: a discussion of the economic considerations for the primary metals comprising the candidate alternatives, and the physical or technical considerations of the selected alloys and cladding combinations.

2.0 ECONOMIC CONSIDERATIONS

2.1 Introduction

The candidate materials: copper, zinc, iron, aluminum, magnesisum, manganese, and nickel, are reviewed in this section with respect to their availability and price. This evaluation is based on ore availability and its reliability of supply; characteristics of the particular industry,

from mining and ore concentration through the production of coins and multi-layer composite; growth trends in non-coinage uses; and price trends and stability.

2.2 Copper

U.S. production of copper ore continued to rise through 1974 to a level of 293 million short tons on a gross weight basis. The reduced rate of growth of ore production between 1973 and 1974--only one percent--was primarily the result of labor strikes and the reduced demand resulting with the recession. Also, the General Services Administration (GSA) released a large quantity of copper for sale to industry. Growth in the production of ore during the current year is expected to recover toward historical levels--in the range of 10 percent per year--as new mine capacity is developed and discrepancies in compliance with air quality standards are resolved. The lowered yield of recently mined ores, however, implies that a return to the historical production rate will be accompanied by higher prices of both ore and refined copper.

Reserves of copper in the U.S. are currently estimated by the U.S. Bureau of Mines to be in the vicinity of 90 million short tons on a metal content basis. This represents approximately 20 percent of currently estimated world reserves. World and U.S. copper resources are estimated to be from three to four times their respective reserve estimates, although these figures are highly tentative. The reserve estimated for the U.S. will support the current level of domestic production for an additional 56 years. However, this horizon is perhaps understated, for several reasons: some resources might be considered reserves as copper prices rise and additional information is obtained; copper consumption growth should slow as copper prices rise; and imports of ore will probably be relied upon to a greater extent as domestic copper production slows relative to domestic copper consumption.

In 1974, U.S. consumption of refined copper fell to approximately 2.2 million short tons from a consumption level in excess of 2.4 million short tons in 1973. Both figures may have been greater if copper prices had not risen to help ration available supplies from stocks

and new production. The rapid increase in copper prices stimulated speculative buying during 1973, suggesting that these "consumption" figures may reflect stockpiling as well as actual consumption.

Primary copper production fell from a level of more than 1.8 million short tons in 1973 to a level between 1.6 and 1.7 million short tons in 1974. This decrease occurred in response to declining consumption and prices, and growing inventories. Secondary copper production remained essentially constant at a level slightly under one-half million short tons. Refined copper imports rose slightly more than 50 percent between 1973 and 1974, from 0.2 to 0.3 million short tons.

The long-term supply outlook for copper in the U.S. and the world indicates no major shortages as lower grade ores are mined, particularly in the U.S. Occasional shortages and resultant temporary price increases may occur in response to labor strikes and political developments, particularly in Chile, Peru, Zambia, and Zaire, all of which are major producing countries. Complicating the problem of lower grade ores currently being mined in the U.S. are environmental factors; including the problems of controlling sulfur dioxide emissions from copper smelters, and the strip mining and land reclamation controls applicable to copper mining. These factors will serve to slow the rate of growth of domestic refined copper and to raise its price over time.

Currently, electrolytic copper is approximately $0.75 per pound, after rising from an average price of $0.595 per pound in 1973 to a high of slightly over $0.81 per pound in May 1974. These are U.S. producer prices and are somewhat artificial in that price controls were applied to copper through April of 1974. Copper prices on the London Metal Exchange, which were uncontrolled but are traditionally more volatile, rose to a high of approximately $1.41 per pound over the same period. This historic rise in copper prices, terminating in the second quarter of 1974 was the result of several contributing influences: record usage levels; worldwide inflation and speculative flight from currencies during the oil embargo period; anticipation of labor strikes in the U.S. since most major contracts expired in mid-1974; and various other production difficulties. The return toward historic price

trends after this period resulted from several developments, including the release of copper from the General Services Administration stockpile; a reduction in demand pressures, especially in Japan; and a reduction in the threat of a major strike. An attempt by the major producing countries during 1974 to establish a system of price stabilization for future years failed.

Major production and price increases are probably as much as a year away, although the price could rise to the low seventies by the end of the year if the current recovery continues. The longer term (through 1985) outlook for copper prices is generally in the $1.00 to $1.25 per pound range, sufficient to bring new refinery capacity on line. If this long-term price trend continues, copper will average $1.50 per pound by 1990. This long-term price would result in an approximate doubling of the current materials cost of a cent, and raise the materials cost of other coinage by a slightly smaller multiple.

Copper prices for any given year of this projection period could exceed these average values by a substantial margin. The ratio of high prices to average prices for copper on the London Metal Exchange over the 1950 to 1974 period has ranged from a low of 1.00 in 1963 to a high of 2.10 in 1974; during 1973 and 1974 this ratio approached 1.60. If the latter figure is used as a guide for copper price volatility, then the 1990 price for copper could reach $2.40 per pound on a temporary basis. The time duration of the historic copper price peaks has not been long, however, so appropriate U.S. Bureau of the Mint procurement policies might be able to circumvent the short-term copper price volatility problem of copper purchases. However, speculative private hoarding of copper cents cannot be supressed. The longer-term price trend cannot be avoided by such policies.

The major uses of refined copper are as follows: electrical equipment and supplies (50 percent); non-electrical industrial equipment (10 percent), transportation (12 percent); construction (16 percent); ordinance (6 percent); and miscellaneous uses (6 percent). Limited substitution possibilities, such as aluminum for copper wiring in residential applications, exist at the present time, although more extensive substitution may be feasible in the near future.

Currently 10 copper-producing companies in the U.S. operate 17 smelters and 18 refining facilities. These companies own a majority of the 75 copper mines in the U.S. A high level of research, development, and testing activity is currently under way as the industry searches for mining, smelting, and refining techniques that are both environmentally compatible and energy efficient. This activity is likely to ensure the ability of the industry to serve, in conjunction with imports and the recovery of copper from scrap, the historical growth trend in domestic copper use.

2.3 Zinc

Domestic production of zinc from ore totaled 0.5 million short tons (zinc content basis) in 1974, a level slightly greater than the two previous years but below production levels during the five previous years. Imports of ore on a zinc content basis declined sharply to 1972, and since then have stabilized in the vicinity of one-half the level of domestic production. World production of zinc declined to 5.7 million short tons in 1974, from 6.2 million short tons in 1972.

Domestic zinc reserves are estimated at 30 million short tons (zinc content basis). This reserve level can support the 1974 production level for an additional 60 years, subject to all the qualifications on interpretation of this horizon as cited in previous sections. Domestic zinc resources are estimated to be 50 million short tons (zinc content basis). World reserve and resource levels are estimated to be 149 and 121 short tons, respectively. Thus domestic reserves comprise approximately 20 percent of world reserves, and domestic resources comprise a slightly smaller percentage of world resources.

U.S. consumption of slab zinc has closely followed movements in the general economy, especially automobile production. This consumption declined from a level of over 1.4 million short tons in 1972 to a level under 1.3 million short tons in 1974. Domestic production from ores and from scrap has been static over this period, remaining in the vicinity of 0.7 million short tons. Almost one-half of zinc smelters operating in 1969 have now closed, with only eight currently in operation. Zinc supplies were augmented in 1973 and 1974 by shipments from the GSA

stockpile, although that supply has now been essentially depleted. Imports of slab zinc increased in 1972 and currently total between 0.5 and 0.6 million short tons. Thus imports as a percentage of domestic slab zinc consumption has risen from less than 25 percent in the late 1960's to approximately 50 percent at the present time.

Zinc consumption has grown at a long-term rate of approximately 2 to 3.5 percent per year, and is especially vulnerable to fluctuations in automobile demand. Zinc supplies are expected to continue to be tight over the near future, with expansions in domestic consumption relying on increases in imported slab. London Metal Exchange prices of zinc soared in 1973 along with all non-ferrous metal prices U.S. producer prices, subject to price controls, remained substantially lower. However, the latter prices rose in 1974 to an annual average of $0.36 per pound--from $0.31 at the start of the year--and have risen further to slightly below $0.40 per pound at the present time. Thus, zinc prices have increased to approximately two-thirds the price of electrolytic copper at the present time.

The primary market for zinc is zinc-based alloys, which are used principally in die castings. This use represents 33 percent of zinc consumption. Other major uses include galvanizing (27 percent); brasses and bronzes (21 percent); and zinc oxide (10 percent). This composition is likely to change with time, particularly as lighter weight private automobiles are introduced. The extent of substitution of materials such as aluminum, plastics, and magnesium for zinc in this use category will depend on the availability of prices of these alternative materials.

Given the current slab zinc domestic production difficulties and the likelihood of some substitution for zinc in consumption, a three percent annual growth rate in zinc consumption through 1980 may be somewhat optimistic.

Zinc prices are likely to remain in the 40-50¢ per pound range through the projection period to 1990 barring any unforeseen major developments. This predictions based on an almost imperceptible price trend for zinc over the recent past plus an extension of the lack of volatility in zinc prices.

2.4 Iron

Domestic production of iron ore has been erratic during the last four years, declining from 89.9 million long tons (gross weight basis) in 1970 to 75.4 million long tons in 1972, rising to 87.7 million long tons in 1973, and declining once again to 84.4 million long tons in 1974. World production has increased continuously over this period with the exception of a lull in 1972. Figures for 1974 are not available at the present time, but 1973 world production totaled 850.7 million long tons. Imports for consumption have increased during the last two years, from a five-year low of 35.8 million long tons in 1972 to a peak of of 48.0 million long tons in 1974. The majority of these imports were from Canada and Venezuela.

Domestic iron ore reserves are estimated at nine billion long tons, of which approximately two billion is estimated to be recoverable iron. Domestic iron ore resources are estimated to be in the range of 90 billion long tons, 16 billion of which are estimated to be recoverable iron. Comparable values for world reserves are 240 billion long tons, 95 billion of which are estimated to be recoverable iron. World resources are estimated at over 420 billion long tons, 150 billion of which are estimated to be recoverable iron.

Production of pig iron in the U.S. has closely paralleled domestic iron ore production over the last five years. The 1974 production level of 95.5 million short tons decreased from the 1973 level of 100.9 million short tons. Shipments for domestic consumption have followed a similar pattern, totaling 95.9 million short tons. The excess domestic consumption over domestic production was met by imports over this period (exports of pig iron are essentially negligible). World pig iron production has increased continuously over this period, so that domestic production of pig iron declined as a percentage of world production. Major world pig iron producers other than the U.S. include the U.S.S.R., Japan, West Germany, and the People's Republic of China. Only Russia and the People's Republic of China are also major iron ore producers; other major iron ore producers include Australia, Brazil, and Canada. The U.S.S.R. dominates both categories, producing more than 25 percent of the world's iron ore, and over 20 percent of the world's pig iron.

Approximately 95 percent of domestic pig iron production is consumed in steelmaking. Only two percent is used in making ingot molds and direct castings. The boom in the worldwide steel market during 1973 and 1974 and the removal of price controls caused the composite price of pig iron to rise sharply, from an average price in the mid-seventies during 1973 to an average price of $129.39 per short ton in 1974. The composite price is currently $187.67 per short ton. The slackening in iron and steel demand resulting from the recession is being compensated for by expanding requirements in the energy-producing and related industries.

Since steel is the most fundamental and pervasive product in modern industrial societies, its forms and uses are difficult to catalogue. Steel production is typically categorized into steel mill products, ferrous castings, and steel forgings. Growth in each category is projected to occur at the rate of approximately three percent per year through 1980. Several factors work to enhance the likelihood of significantly expanded domestic steel mill capacity over this period. Thus, there should be no serious supply dislocations of steel, iron ore or pig iron production available to markets in the U.S.

Steel prices may be expected to average below $0.25 per pound through 1990 on a long-term trend basis. Short-term price movements may increase the average steel price beyond $0.25 per pound but not to any significant extent, since historical steel price volatility has been very modest. Specialty steels are not considered here. They would not be appropriate for coinage since the most important reason for considering steel-core coinage is its lower materials cost.

2.5 Aluminum

The primary ore for aluminum metal at the present time is bauxite. In 1974, the U.S. consumed about 22 percent of the world's bauxite production. Only 12 percent of U.S. consumption was produced domestically; domestic production of bauxite totaled over 1.9 million long tons in 1974, whereas bauxite imports totaled over 14.3 million long tons. Jamaica supplied approximately 54 percent of these imports and Surinam

supplied 23 percent. An additional 0.8 million long tons of bauxite was imported into the Virgin Islands to be refined into alumina. Total world production of bauxite in 1973 equalled 77.0 million long tons.

Domestic production of alumina, or refined bauxite that is further refined by reduction to produce aluminum metal, totaled over 7.6 million short tons in 1974. This is slightly less than 50 percent of the 1973 world alumina production of 31.7 million short tons. An additional 3.6 million short tons of alumina were imported in 1974. Approximately 50 percent of these imports were supplied by Australia; Jamaica supplied 2.2 percent, and Surinam, 18 percent.

Current estimates of bauxite reserves in the U.S. total 40 million long tons: sufficient to sustain the 1973 domestic production level for an additional 21 years. This horizon is likely to be underestimated, however, for the reasons cited in the previous section on copper. World reserves of bauxite are currently estimated at 15.5 billion long tons. No resource estimates are currently available, although aluminum is the most abundant metallic element in the earth's crust. The U.S. Bureau of Mines is currently examining several alternative aluminum-bearing ores, including alunite, anorthosite, damsonite, saprolite, aluminum-phosphate rock, and high-alumina clays. The latter source appears to have the greatest potential for commercial applicability.

Domestic consumption of aluminum metal rose to 5.9 million short tons in 1973, a gain of 0.2 million short tons over 1973 consumption. These figures exclude shipments from the GSA stockpile of 0.7 and 0.5 million short tons in 1973 and 1974, respectively. Domestic production of primary aluminum rose from 4.5 to 4.9 million short tons over this same period. Secondary aluminum typically adds slightly less than 1.0 million short tons. Aluminum imports for consumption have been quite variable over the past several years, although they stabilized somewhat during 1973 and 1974 at slightly over 0.6 million short tons.

The aluminum refining industry is currently operating near capacity and is apparently reluctant to expand capacity significantly until aluminum prices improve. Two reasons for this reluctance are obvious: aluminum refining is the most energy-intensive of the primary metal industries and is thus quite sensitive to past and future hikes in energy

prices. Also, the formation of the International Bauxite Association in 1974 led to a five-fold increase in the export levy on bauxite from the constituent countries which include the traditional suppliers of bauxite and alumina to the U.S. market (with the exception of Australia). The Aluminum Corporation of America (Alcoa) is currently completing an electrolytic refinery expected to reduce kilowatt-hour consumption per pound of aluminum produced by 30 percent. Other improvements in efficiency may also help to hold down future increases in refined metal prices that would otherwise result from continued increases in raw material and energy prices. Aluminum prices have risen in the last two years, from an average ingot price of $0.29 per pound in 1973 to a current price of $0.41. Prior to 1974, aluminum prices typically varied between $0.25 and $0.29 per pound on an annual average basis.

Major uses of aluminum by industry as of 1972 include building and construction (26 percent); transportation (18 percent); containers and packaging (15 percent); electric utilities (13 percent); and consumer durables (9 percent). The use of aluminum in the transportation and electric utility industries is expected to increase substantially, primarily for reasons of a high strength-to-weight ratio and high electrical and thermal conductivities. By 1980 the use of aluminum in the transportation industry is expected to exceed the use of aluminum in the building and construction industry, primarily through doubling the quantity of aluminum used in many private automobiles.

Three firms--Alcoa, Kaiser, and Reynolds--dominate the U.S. aluminum industry, owning approximately two-thirds of total capacity. Twelve companies operate 31 reduction facilities, most of which are located near sources of inexpensive power, including the Pacific Northwest, the Tennessee Valley Authority service area, and the Gulf states. The industry structure and the interruptability of power in the Pacific Northwest both seem to indicate that future capacity expansion will proceed at a controlled rate, such that the response of capacity additions to aluminum price increases will be slower in the future than in the past. Attainment of an annual growth rate of six percent through 1980 will thus require continued increases in aluminum prices.

Aluminum prices have been relatively stable over the recent past. Current prices average $0.41 per pound, and the inventory-to-sales ratio for the industry remains high by historical standards. Based on past price trends, it is unlikely that aluminum may exceed the 50-60¢ per pound price range on either a long-term or a short-term basis through 1990. This prediction is conditional upon the assumptions of no major expansion in the demand for aluminum (particularly no major substitutions of aluminum for copper) and of no major successful cartelization of bauxite supplies. This price stability relative to copper, plus the fact that the density of aluminum is less than one-third that of copper so that more than three times as many coin blanks can be formed from a pound of aluminum than can be formed from a pound of copper, makes aluminum very attractive as a low-valued coinage candidate from a materials cost standpoint.

2.6 Magnesium

Although magnesium is the third most abundant metal in the earth's crust, following aluminum and iron in that order, production of magnesium metal in the U.S. utilizes brine. The magnesium-bearing mineral dolomite is used as a source of magnesium metal in Europe. The Aluminum Corporation of America has acquired a license to operate similar plant in the U.S. that is expected to enter commercial production in 1976. Dolomite is used domestically as a flux in iron- and steel-making. Magnesite, a mineral that also contains magnesium, is currently mined for the ultimate production of certain magneisum compounds, but not magnesium metal.

No current estimates of magnesium reserves or resources are available. Magnesium resources are practically limitless because of the abundance of magneisum in both the earth's crust and in brines (sea water and salt lakes).

Domestic consumption of magneisum metal has risen steadily since 1971. The 1974 consumption level totaled 129,319 short tons, increasing from 115,558 short tons in 1973. Similar increases in magnitude were experienced during the two previous years. Domestic production of magnesium metal totaled 120,823 short tons in 1972 and 122,431 short tons

in 1973.[1/] Imports for consumption have varied erratically over the recent past: 4,479 short tons in 1972; 3,325 short tons in 1973; and 5,305 short tons in 1974. A portion of magnesium requirements were met through reductions in the GSA stockpile.

Magnesium metal is consumed in two broad categories: structural products such as castings and wrought products, advantaged by the metal's low weight and moderate strength; and distributive applications such as alloys and other uses, advantaged by the metal's chemical properties. Approximately one-third of current consumption is for structural uses and two-thirds for distributive uses. Magnesium is expected to compete with aluminum in lighter weight automobiles produced in the future. Domestic shipments of magnesium metal are projected to increase by 4.7 percent per year through the remainder of this century.

Three companies--Dow Chemical, American Magnesium, and NL Industries--currently operate plants in the U.S. A fourth company--Alcoa--is expected to begin operation in 1976. Dow Chemical controls approximately two-thirds of current capacity. The American Magnesium plant is currently shut down, after a series of startups and shutdowns since 1971. The NL Industries plant has yet to produce at full capacity. These supply difficulties along with soaring energy costs, wage settlements, a steadily rising world demand, elimination of the GSA stockpile, and the removal of price controls have been responsible for the recent rapid increases in the price of aluminum metal. Magneisum production is more energy intensive than aluminum production. The average price during 1972 and 1973 remained in the $0.37 to $0.38 per pound range, but rose from $0.41 to $0.75 per pound from January to December 1974. The price rose further to $0.82 per pound on January 1, 1975 but has stabilized somewhat since that time. These price increases should help to encourage domestic production, provided current technical dfficulties in production can be overcome. Improvements in extraction technology, especially those designed to increase energy efficiency, can be expected to facilitate the capacity expansion required to meet demand.

2.7 Manganese

Domestic production of manganese ores totaled 34,804 short tons (gross weight basis) in 1974. The manganese content of these ores

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[1/] 1974 data are not currently available.

was between 5 and 35 percent range. Imports of such ores in 1974 totaled 593,000 short tons recorded on the same basis. These imports represented approximately 2.5 percent of the 1974 world production level of 24 million short tons.

No domestic reserves of manganese are recoverable at current manganese prices. Manganese resources in the U.S. are estimated at 65.7 million long tons on a metal content basis. The world reserve level is estimated on the same basis as 1.8 billion long tons, and world resources are estimated to be in the vicinity of five billion long tons. A large portion of world reserves is contained in deep sea manganese nodules, posing legal problems of ownership as well as mining rights. Barring serious problems in this regard, one domestic firm anticipates production from Pacific nodules by 1980. These nodules often contain deposits of nickel, cobalt, and/or copper associated with the manganese, which would be in some cases a more valuable prime objective.

Domestic consumption, production, and imports of manganese are typically categorized into high-carbon ferromanganese, medium- and low-carbon ferromanganese, silicomanganese, and manganese metal. Another category, spiegeleisen, is sufficiently small that it can be ignored. Ferromanganese consumption in the U.S. totaled 1.1 million short tons (gross weight basis) in 1974, approximately 87 percent of which was high-carbon ferromanganese. Domestic ferromanganese production totaled over 544,000 short tons and imports totaled over 421,000 short tons. The average manganese content of production and imports was 78 percent. Silicomanganese consumption in the U.S. was 177,000 short tons (gross weight basis) in 1974. Domestic silicomanganese production was 196,000 short tons, and imports exceeded 67,000 short tons. The average manganese content in this case was 67 percent. Manganese metal consumption in the U.S. totaled approximately 35,000 short tons in 1974. Domestic manganese metal production totaled over 27,000 short tons and 2,500 short tons were imported. These consumption levels are up by 15 to 20 percent from 1972 levels in each case.

Approximately 80 percent of domestic manganese consumption is used in the form of manganese alloys and metal. Other uses in order of importance include pig iron and steel, and dry cells and chemical processing.

Manganese is especially useful as a desulfurizing agent in steel. Manganese holds a preemptive position in steel-making and only limited substitution possibilities exist for materials such as chromium, nickel, molybdenum and boron substituting for manganese in ferroalloys. The current market situation is one of tight supply, reflected in the fact that ferromanganese has climbed from $200 per long ton in January 1974 to $440 per long ton at the present time. A portion of this increase also reflects the removal of price controls. Manganese metal jumped from approximately $0.35 per pound to $0.54 over the same period.

A separate study reported a projection which suggests that domestic consumption of primary and secondary manganese may increase to 2.1 million short tons (gross weight basis) by the year 2000, and that world consumption may rise to 18.3 million short tons. These figures, when cumulated to the year 2000, are safely within current estimates of world reserves. This growth in domestic consumption must assume either successful development of deepsea nodules on a major scale, or else a continued successful reliance on traditional suppliers of imports. Primary suppliers include Brazil, Gabon, and Zaire for ore, and South Africa, France, Japan, and Norway for ferromanganese.

2.8 Nickel

Nickel is primarily employed as an alloying agent for excellent corrosion resistance. U.S. mine production of nickel ore totaled 16.6 thousand short tons (nickel content basis) in 1974. This figure is approximately equal to the average production level for the past several years, and represents approximately two percent of world production of 825.7 million tons in 1974. Canada continues to be the predominant producer, although the Australian share has been gaining recently.

Nickel reserves in the U.S. are currently estimated at 10.2 million short tons (nickel content basis). These reserves are sufficient to sustain the 1974 level of domestic production for an additional 12 years. This horizon is understated, however. Although no domestic estimates are available, U.S. Bureau of Mines personnel indicate that no major domestic supply problems should occur prior to the turn of the century. Recent rapid increases in nickel prices may now make recovery of nickel from low-grade ores that are not listed in the reserve figures economically attractive.

Domestic consumption of nickel rose to 208.4 thousand short tons in 1974, up by approximately 25 percent from 1972. Imports for consumption have risen by approximately the same percentage, to 220.7 thousand short tons in 1974. Secondary nickel production in the U.S. currently exceeds primary nickel production by a factor of three. Approximately 20 percent of primary nickel production is a by-product of copper refining. Domestic primary nickel production totaled approximately 14.1 thousand short tons in 1974.

The use of nickel in stainless steels accounts for approximately 33 percent of domestic consumption. Other major uses include electroplating (16 percent); speciality steels (13 percent); and super alloys (6 percent). Currently many substitution possibilities for nickel exist, and although none are fully acceptable on technical grounds, they may be undertaken in response to the recent rapid increases in nickel prices. Nickel prices rose from $1.53 to $2.01 per pound over 1974, and the current price is in the vicinity of $2.20 per pound. These prices may stimulate the domestic production of nickel from low-grade sulfide deposits in Minnesota. In the near-term future consumption from stockpiles and substitutions for nickel in end uses are likely, whereas the long-term supply prospects look favorable given the recent trend in nickel prices.

Future nickel prices are difficult to predict. On the one hand, they are heavily influenced by wage settlements in Canadian mines as well as Canadian mineral and export policies. On the other hand, future price increases are to some extent constrained by the availability and prices of substitute metals--although these metals may be far inferior to nickel in those applications for which nickel is desired--and also by the availability of lower grade deposits outside Canada. In any case, the consideration of nickel as a coinage material should be limited to that of an alloying element for intermediate or high-valued coinage.

3.0 TECHNICAL CONSIDERATIONS

The physical properties of the candidate coin materials affect the technical requirements for coin manufacturing and discrimination, and the aesthetic properties of the resulting coins. In this section of the report the technical characteristics of the candidate alternative materials are discussed, and the most promising candidates for coins are identified. An analysis of the technological and cost impacts of coins fabricated from the most promising candidate materials is deferred to subsequent chapters.

3.1 Evaluation Criteria

The criteria identified previously as relevant for evaluating coinage alternatives include:

a. Compatibility with existing equipment - The extent to which coin alternatives may be processed in existing coin validators, counters, sorters, changers, packagers, and other processing or storage equipment.

b. Cost - Total manufacturing and distribution costs of the coin system.

c. Durability - The ability of the coins to withstand wear resulting from use in circulation.

d. Eddy Current Discrimination - The degree to which a coin may be discriminated from other coins or slugs in a magnetic field.

e. Aesthetic Appearance - Attractiveness of form, design, and color; susceptability to tarnishing or corrosion.

f. Commercial Efficiency - The extent to which the mix of coin denominations are convenient and useful for commercial transactions.

g. Mechanical Discrimination - The degree to which a coin may be discriminated from other coins or slugs through tests of its mechanical properties.

h. Public Acceptability - Convenience to individuals; based on coin size, weight, and ease of manual or visual discrimination among denominations.

i. Seigniorage Protection - The extent to which the face value of a coin exceeds its material plus manufacturing cost.

Several criteria listed above are solely technical considerations, depending upon the physical properties of the material; but for most of the criteria the technical aspects are only partial determinants of overall acceptability. The influence of the technical characteristics of materials with regard to the criteria is summarized as follows:

Total	Partial	None
Durability	Compatability with Existing Equipment	Commercial Efficiency
Eddy Current Discrimination	Cost	
Mechanical Discrimination	Aesthetic Appearance	
	Public Acceptability	
	Seigniorage Protection	

Inherent conflicts exist among many of the criteria. For example, an objective of minimizing cost is counter to the objective of protection from slugging or counterfieting. A material that is not readily available is not likely to be inexpensive and offer ample seigniorage protection. However, slugging protection is more important in terms of selecting a material for the one dollar coin, while seigniorage protection is more critical for the selection of material for the one cent and two cent coins.

3.1.1 Manufacturing Requirements

The physical properties of coinage materials dictate the manufacturing technology and process requirements necessary to manufacture coins in an efficient and cost effective manner. The material selected for these coins must not only be economical in terms of its intrinsic value, but also in terms of its "coinability". Coinability refers to the ability to produce coins of high quality at low manufacturing costs. Some of the materials discussed in the introduction to this chapter were rejected because they would be difficult to coin.

This evaluation includes fabrication parameters as well as the value of the scrap resulting from the coining process.

3.1.2 Discrimination Requirements

Several considerations are important for coin discrimination. A coin must be durable; retaining its original configuration and weight after vigorous use in order to continue operating in a consistent manner in coin processing equipment. The coin must also be secure from slugging. In this case, coinage materials should not be readily available on the open market, nor should it be easy to substitute lower-valued foreign coins for higher-valued domestic coins in vending.

Discrimination against unwanted coins or counterfeited slugs is based on physical properties. Among them are the deceleration of a rolling coin through induced eddy currents, simple weighing, and magnetic separation. Eddy current devices, the most widely used mechanism for discriminating coins in vending machines, accept coins as valid if the "acceptance factor"[1/] of the coin is in a given range.

3.1.3 Aesthetic Requirements

There are no purely objective standards for judging an aesthetically appealing coinage material; tradition determines "acceptability." However, colors associated with value, such as gold or silver; resistance to tarnishing or surface blemishes; durability; and distinctness of engraving are all related to materials selection.

3.2 Evaluation Approach

The analysis of the technical characteristics of candidate materials was conducted by three different means: extensive discussions with manufacturers and potential vendors of metal or coinage strip for the alternative materials; review of published data by expert consultants; and laboratory and experimental production tests conducted by the Bureau of the Mint. By the first two approaches it was observed that a very

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[1/] The acceptable performance of alloys in eddy current mechanisms can be approximated by the product of the coinage material's electrical resistivity and density, called the acceptance factor.

wide range of materials are feasible for manufacturing coins, but as analyses by the Mint have demonstrated and additional research has confirmed, the range of economical and efficient options is considerably more narrow. A quick survey of the materials in use for coins throughout the world further confirms this finding.

The Department of the Treasury conducted an extensive analysis of alternatives materials for one cent coinage in 1973.[1/] An independent analysis of the economic and metallurgical properties of an extensive list of materials, conducted during the present study, confirmed the validity of the Bureau of the Mint's earlier finding: that the primary candidates for one cent coinage are copper-zinc alloys, copper clad or steel, and aluminum. In addition, these three candidates were also determined to be the only viable materials for a two cent coin.

No production experiments were conducted with the candidate materials during the RTI study. The Office of Technology of the Bureau of the Mint, under the direction of Dr. Alan Goldman, Assistant Director of the Mint for Technology, conducted laboratory and production experiments with the above materials during the 1973 study. Those experiments were not full scale scientific experiments to determine the optimum mix of alloys and manufacturing parameters for each of the candidate materials; but they did generate the maximum information possible about manufacturing requirements for the materials within the constraint of time and resources available for the experiment.

After a review by RTI of the data generated from the previous experiments, extensive discussions with the participants in those experiments, and a survey of foreign and U.S. coinage data, RTI and the Mint agreed that the additional data to be gained from further experiments would not justify the additional necessary expenditures and manpower commitment. Therefore, the description of the technical characteristics of the alternative one and two cent materials contained below are based on the findings of the 1973 Bureau of the Mint experiments and additional technical data furnished by expert consultants.

[1/] U.S. Department of the Treasury, Alternative Materials for One Cent Coinage, December 1973.

With the candidate alternative materials for the one dollar coin, the Bureau of the Mint has performed wear and corrosion tests and limited coinability tests. The Bureau of the Mint directed a wear and corrosion tests program, using approximately sized sample blanks, at the research and development facilities of Texas Instruments, Inc. in Attleboro, Massachusetts. These tests were designed to evaluate the simulated effects of wear and atmosphere on coinage materials.

THe experimental production or coinability, tests of the alternative dollar materials were limited to laboratory experiments by the Bureau of the Mint. Relevant production experience also has been gained by the Mint in manufacturing foreign coins and commemorative metals. The data thus accummulated were sufficient for the evaluation of technical considerations of the dollar coin.

3.3 Cent Alternatives

3.3.1 Survey Preferences

The surveyed groups of coin users included retail firms, commercial banks, automatic merchandising service firms, manufacturers of coin equipment, and transportation systems operators.[1/] An overwhelming majority of respondents in these groups indicated their preference for the material or "color" of a two cent coin as "brass". Several manufacturers of coin processing equipment commented more specifically on their preferences that the two cent coin should be:

> "Same as existing pennies acceptable; if changed we prefer a faster material 70 percent copper - 30 percent zinc."

> "Not aluminum - too light - use most economical combination that can be produced with smooth edges."

3.3.2 Copper-Zinc Alloys

Commercially pure copper is rather soft for coinage purposes. The addition of zinc, (five percent in the current cent) increases the strength of the material without signficantly altering the coinability.

[1/] See Appendix B for a discussion of the survey methodology.

Since the Bureau of the Mint manufactures nearly 10 billion 95 percent copper-5 percent zinc cents per year, the physical properties and manufacturing requirements are well known to them.

Copper has an acceptance factor somewhat below that of coin silver. The actual value (15) is not so low that it cannot be adjusted by alloying with a metal of higher resistivity. The current cent material has an acceptance factor of 27; with 30 percent zinc, the acceptance factor increases to a value of 53.

Copper alloys with zinc contents up to 35 percent, commonly known as brasses, have been used as coinage materials throughout the world. The addition of zinc changes the color from the well known penny bronze (95 cu-5 zn) to a cartridge brass (70 cu-30 zn). For low-valued coins, the tarnishing behavior of these materials is not objectionable from an aesthetic point of view.

The manufacturing requirements for brass differ from those of penny bronze. The annealing temperature for brass is 1,275°F compared to the 1,400°F of penny bronze, so the annealing process is expected to be approximately 25 percent longer. Brass is a harder material than the penny bronze, so a coinage force of 45 to 50 tons will be required as compared with the 35 to 40 tons for penny bronze. Consequently, die life would be shorter for the brass (approximately 75 percent of the die life for 95 cu-5 zn).

Copper rarely suffers galvanic corrosion since it is cathodic to such common metals as iron, zinc, aluminum, magnesium, lead, and tin.

3.3.3 Copper Clad Steel

A sandwich material of copper or a copper-zinc alloy clad over a mild steel core has found limited acceptance in other countries as a material for low-denomination coinage. This material has the advantage of a very low metal cost for the steel core. Offsetting the advantage are the problems of disposing of large amounts of essentially worthless scrap, difficulties in annealing the material, and high stamping forces necessary for coining.

The present metal cost advantage of copper clad steel is largely negated by the higher strip fabrication costs.[1/] The net current advantage was a 3.3 percent savings, which would increase as the price of copper rises relative to steel.

In 1973 the Bureau of the Mint conducted a limited production run of approximately 500,000 clad steel blanks. The experiment was not an optimizing experiment in the sense of determining the best way to produce bronze clad steel one cent coins but did provide accurate information about the production characteristics of the material within the context of the existing coinage production system.

The blanking process created no problems and generated approximately one-half million blanks for test production. The tests at the Mint yielded fully annealed blanks, but the annealing furnance temperatures were raised beyond their normal capacity to generate the annealed blanks, and a continuous production utilizing the annealing process would be detrimental to the annealing furnaces. The annealing process involved dividing the annealing furnaces into zones and annealing in zone 1 at 1650° and zone 2 at 950°. The problem with clad steel is that the annealed coins must cool more slowly than the bronze coins and a quenching step cannot be used with clad steel, thus the annealing process must allow the blanks to cool down more than the current production process. Suitable annealing furnaces could be developed to perform the task at the Mint or the existing furnaces could be modified to meet the needs of annealing. However, the existing furnaces will not work as presently designed.

In the experimental production the cleaning process and the upsetting process were satisfactory. In the coining operation the critical problem was the die pressure necessary to produce a full relief on the 1974 production penny dies. The bronze pennies require 40 to 41 tons per coin of force to produce a maximum relief of twelve thousandths. In contrast the West German one and two pfennig coins of clad steel have

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[1/] Olin provided the following estimates for furnishing coin strip, February 12, 1976:

	95 cu-5 zn	90 cu-5 zn clad or steel
Total cost per pound	70.94¢	58.29¢
Total cost per foot	122.01¢	117.94¢

less than five thousandths relief. The load needed to acceptably, but not completely fill relief took 68 tons per coin for the bronze clad steel (10-80-10 clad). Mint data indicated that the die life for the clad steel coins was approximately 100 to 150 thousand coins per die, compared to the 600,000 coins per die rate for bronze cents.

In summary, the coining tests accurately reflected the requirements to produce the clad steel coins under the existing production sequences and processes and coin relief. The following elements were the key factors: first, the degree of relief; second, the thickness of the clad; and third, the annealing furnace. The degree of relief is the primary factor which determines the coining forces necessary to stamp the engraving on the coin and in turn determines the life of the dies. Accepting less relief would improve the production characteristics associated with clad steel and make it a more acceptable alternative. Assuming no changes in the degree of relief, the thickness of the clad material will dictate the coining forces necessary to strike the coin. A 10-80-10 clad requires 68 tons per coin to strike. A thicker clad would require less tonnage because the cladding would absorb the impression rather than the steel core. However, a thicker clad would reduce the economics associated with clad steel very rapidly. As mentioned before, the annealing process was considered to be a problem which could be resolved with either replacement or modifications of the annealing furnaces currently in use at the Mint. However, new furnaces or modifications to the existing furnaces would require a substantial capital investment.

There are two other objections to copper clad steel. First, the coins would be magnetic with a high acceptance number. Second, there is the scrap problem. Approximately 50 percent of the coinage material would end up as scrap, and at present no alternative uses for the clad scrap material are known. As "No. 1 dealer-bundled scrap," the material's highest use, the scrap would be worth approximately $.05 per pound.

The materials cost advantage of steel-core coinage over copper appears to be more than offset by higher strip fabrication costs, a lower price recovery factor from the clad scrap, and lower die life as a result of higher hardness values for this type of coin, rendering this material unacceptable for the minor coin denominations.

3.3.4 Aluminum

The material characteristics of aluminum resembles that of copper in some important ways; it has good formability, its mechanical properties can be controlled by alloying additions, and it has high electrical conductivity. Its low density compared to copper is a disadvantage that affects the subjective "feel" of an aluminum coin as well as its behavior in coin-operated devices. This also applies to all aluminum-rich alloys. Pure aluminum, like pure copper, is rather soft and can be hardened by small additions of alloying elements such as magnesium and/or manganese.

Alloys are found with magnesium contents up to about 10 percent minor additions of manganese and/or chroium. These are usually thought of as hot working heat treatable alloys above seven percent magnesium whereas the lower magnesium alloys are not heat treated. The advantages of adding magnesium are equivalent to those of adding zinc to copper; the metal is hardened but not to the extent that coining becomes difficult.

One minor problem with aluminum is corrosion. Aluminum is actually an active metal and may corrode, but it behaves as a stable metal due to a protective oxide film. Fifty-year-old aluminum coins that received no particular protection can still be seen in excellent condition today. The corrosion hazard should not be completely ignored, though. Aluminum is anodic to other coin materials and thus can corrode by galvanic action in contact with more cathodic coins in the presence of moisture. Also, alkaline solutions like ordinary soap and water may affect aluminum.

The manufacturing characteristics of aluminum are well known to the Bureau of the Mint. The Mint has manufactured aluminum coins for foreign nations, and the Office of Technology conducted extensive laboratory and manufacturing tests with aluminum in 1973. During those tests over one-half million test strikes with type 5005 aluminum and over one million strikes with type 3003 aluminum were completed. The tests included variations in blanking and striking forces, upsetting and not upsetting, and variations in lubrication procedures.

The results of the 1973 tests indicated that aluminum strip could be blanked at least as rapidly as penny bronze strip. Significantly, no annealing was required for the aluminum blanks prior to striking. The coining forces necessary for the aluminum blanks were approximately one-half that required for the present material, so the blanks could be coined at least as fast as presently. Finally, the length of the experimental production run necessary to obtain accurate die life data would have been prohibitive; but the data generated indicated that a die life approximately 75 percent as long as with the present cent could be expected. This lower die life would be due to wear and dulling caused by the abrasive natural oxide larger formed by aluminum.

From a manufacturing perspective, the significant aspects of aluminum are its ease of fabrication and lack of annealing requirements (contrasted with the material hardness and additional annealing requirements of copper clad steel). Foregoing the annealing will signficantly reduce energy and resource requirements and will free up valuable manufacturing space.

The use of aluminum as coinage would encounter difficulties in vending. Many of the vending machines employed for automatic merchandising now automatically reject copper cents. This rejection is accomplished by the weight of the cent pushing aside a cradle in the coin acceptance mechanism. The ligher weight aluminum cent coin could not activate this automatic rejection: the consumer would have to release the coin manually by depressing the coin return button or lever. If other coins were deposited into the machine while an aluminum cent rested in the cradle, they could build up, possibly resulting in a jamming of the mechanism. An aluminum coin's light weight would also cause problems in counting aluminum coins with copper cents in machines where counting is primarily based on weight.

One additional problem associated with aluminum coinage is that aluminum unlike copper is not "radiodense." That is, an aluminum coin is not easily distinguishable from human tissues in x-rays. Therefore any doctor, upon examining an x-ray of a child thought to have swallowed

an aluminum coin must exercise great care in order to discern the presence of the coin. If an aluminum coin were introduced, the U.S. Department of the Treasury should issue educational material alerting pediatricians of the lack of "radiodensity" of aluminum in order to alleviate potential mishaps. Even in light of these shortcomings, aluminum is still considered as a highly desirable alternative material for one or two cent coinage.

3.3.5 Conclusions

Aluminum is the only viable alternative coinage material for the one cent coin, while aluminum and brass are viable for the two cent coin. To compare the costs to the Mint for manufacturing one cent and two cent coins from the alternative materials, the metal costs were projected to 1990.[1/] While brass would provide some seigniorage protection to 1990, the protection that an aluminum coin would provide is almost 10 times as great. Although brass is preferred by the surveyed user groups, aluminum is obviously a more economical material for a two cent coin. However, both aluminum and brass must be considered as alternatives since brass was so preferred by coin users.

3.4 Dollar Coin Considerations

3.4.1 Survey Preferences

With respect to their preferences for the material or "color" of a one dollar coin, approximately 80 percent of the respondents in all groups indicated "silver" as the preferred color for a one dollar coin. During an initial polling, manufacturers of coin processing equipment were requested to provide more specific information on their preferred material. If the half dollar coin were eliminated, 12.5 percent of the respondents preferred a one dollar coin of 75 percent copper-25 nickel, and 12.5 percent would prefer a 75 percent copper-25 percent nickel clad on copper coin. Fifty percent of the respondents either indicated "no preference" or did not respond to the question.

[1/] Cost data are contained in Chapter 7.

With a cocirculating half dollar coin, 18.5 percent of the respondents preferred a one dollar coin of 75 percent copper-25 percent nickel, while 12.5 percent expressed a preference for a 75 percent copper-25 percent nickel clad on copper coin. With this question also, 50 percent of the respondents indicated "no preference" or did not respond to the question.

As Chapter 5 describes, a consensus subsequently was reached among the manufacturers of coin equipment that the optimum material is the present sandwich material.

3.4.2 Physical Properties of the Candidate Materials

The candidate materials for the one dollar coin include brass (the relevant properties of which were discussed earlier), nickel, cupronickel, cupronickel clad on copper and cupronickel clad on nickel.

Pure nickel has excellent corrosion resistance, and when carbon-free, good coinability. Unfortunately, it has a high acceptance factor, and is also magnetic: two properties that are undesirable for current vending purposes.

Because of its high cost, nickel is probably most useful as an alloying element with copper. The common copper-rich alloys are generally referred to as cupronickels and include compositions currently used in all U.S. coins except the cent. Cupronickels are non-magnetic and have good coinability and excellent corrosion resistance. Their acceptance factor is generally too high for current vending mechanisms; here comptability with vending machines has been achieved by cladding over copper.

Cupronickel clad over nickel reduces the acceptance factor value to one-fourth the value for pure nickel. It also results in a decrease in the ferromagnetic moment of nickel, which is already far below that of iron. This combination would be difficult to counterfeit, possible outweighing the need to switch from eddy-current to magnetic discrimination devices. Two domestic companies are now licensed by a German manufacturer for U.S. production and marketing of one cupronickel clad nickel combination. However, this limited licensing of the "Magnimat" material could pose problems for U.S. Bureau of the Mint procurement.

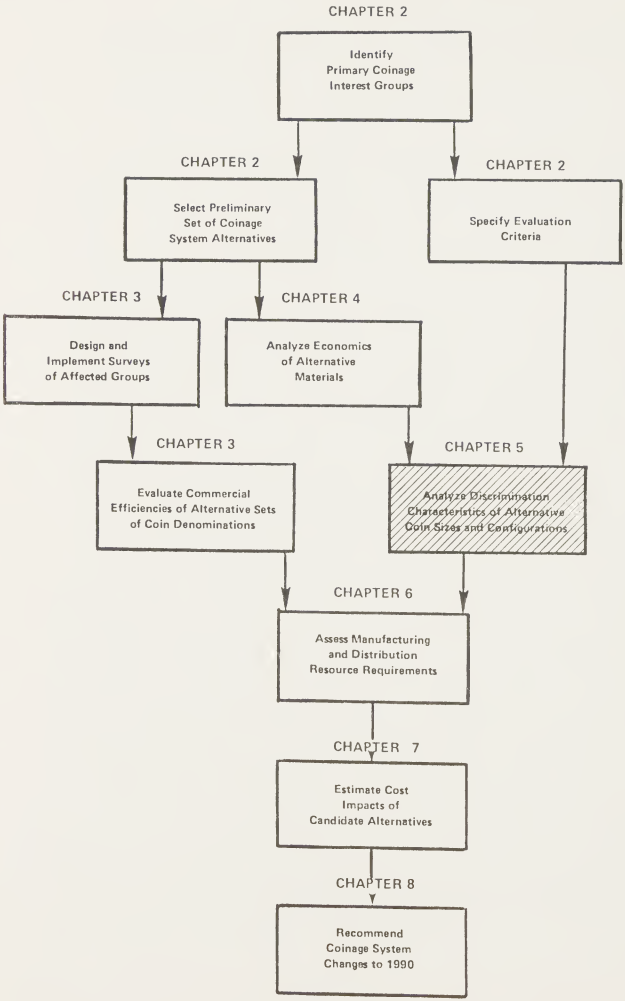
Brass is the only candidate material which is not silver colored and may suffer from lack of public acceptance on that basis. Seigniorage can be easily maintained with any of these materials. More important for a one dollar coin is protection against counterfeiting or slugging. While several of these materials are incompatible with current discrimination technology, increased security might outweigh the costs of changing from eddy current to an alternative method of discrimination.

The difference in slugging protection provided by alternative materials is marginal. Since it is not feasible that the coin be made of gold or some other intrinsically-high-value material, the selected material will also be readily available for counterfeiters. Discrimination in vending mechanisms should consequently rest not only on a material test, but also on alternative parameters specific to the configuration of the coin. Of the candidate materials, cupronickel clad on copper has the advantage of current use and familiarity and is consequently recommended for a more conveniently-sized one dollar coin.[1/]

3.5 Additional Considerations

With the introduction of the one dollar coin and the subsequent increase in the use of cupronickel clad copper strip, a larger quantity of this scrap would result. This scrap is not easily disposed of. Therefore, serious consideration should be given with the introduction of the one dollar coin to coincidently change the material of the 5 cent coin from 75 percent copper-25 percent nickel to 91.67 percent copper-8.33 percent nickel (that is, the resulting scrap material from the cupronickel clad copper). While such an action by the Mint would cut its costs substantially, it would not significantly affect the discrimination of the 5¢ piece in vending machines.

[1/] Additional discrimination characteristics will be discussed in the following chapter.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design and Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 5

Discrimination Characteristics of Coinage System Alternatives

1.0 INTRODUCTION

Discrimination characteristics describe the degree to which a particular coin denomination may be identified, selected, and appropriately responded to as distinct from other coin denominations, foreign coins, and slugs. The purpose of this chapter is to evaluate the candidate alternative coinage sets with respect to their discrimination characteristics.

Discrimination may be facilitated by the various distinguishing characteristics of a coin. There are two general groups of coin discriminators: people and machines. Humans obviously discriminate between coins of different denominations by using their senses. Discrimination can be facilitated by a coin's distinctiveness of color, weight, diameter, thickness, shape, and surface or edge characteristics. Surface or edge characteristics are determined by such factors as the engraving of the coin or whether the edge of the coin is reeded or smooth.

Machine discriminators can be mechanical, electronic, based on an eddy current (or magnetic field), or rely on combinations of these means. Bases for coin discrimination by these methods are the size (diameter and thickness), material, and weight of a particular coin. As discussed in Chapter 4, the material of a coin is important in that it determines the acceptance factor of the coin -- the manner in which the coin is affected by a magnetic field. The material also somewhat determines the security of a particular coin -- that is, the ease with which the coin may be duplicated as a slug by counterfeiters.

This evaluation considered the importance to coin users of various discrimination characteristics. The preferences of groups of coin users recorded through the survey, as well as the compatability of alternatives with existing coin processing equipment were examined in order to select the most preferable discrimination characteristics for the alternatives to the present U.S. coinage system.

Discrimination is obviously important to coin users in general; it is necessary to be able to distinguish between two coins of different denomination in order to insure proper transactions. The nature of this discrimination may vary with the use of the coin as well as the individual using it. Distinct engraving and configuration may be more important to the visually-impaired who would use coins in everyday purchases, while the qualities of the coin's material may be more important to the manufacturer of coin mechanisms.

In order to appropriately evaluate the discrimination characteristics of the alternatives, it was necessary to consider the various groups of individuals who discriminate coins differently.

2.0 LOW-DENOMINATION COINS

2.1 Candidate Combinations of Denominations

The candidate combinations of the low denominations which are the selected alternatives to the current U.S. coinage system include: the present set, which contains the cent and nickel; a set with the nickel as the lowest denomination (eliminate the cent); and a set which contains the cent, a two cent coin, and the nickel (add a 2 cent coin to the present set). The dimensional and configurational characteristics of the one cent and two cent coins must be considered together since their use would be highly interrelated in functional usage and commercial transactions. The one cent coin is also a candidate for a change in composition. If an aluminum or brass two cent coin is introduced to decrease cent requirements, it should be easily distinguishable from the cent and the nickel. In the following sections, these characteristics and their impacts are discussed.

2.2 Size Characteristics

2.2.1 Introduction

Size characteristics include diameter, thickness, and weight. These characteristics affect both human and machine discrimination of coins. It is necessary that the coin be distinctive in feel and appearance,

that it possess a diameter and thickness distinguishing it from other coins to be easily discriminated by people. For purposes of machine discrimination, the size of the coin should not duplicate that of a foreign coin, particularly if the foreign coin is of lower value. In addition, the coin should weigh enough to follow its proper path through a coin validator in a vending machine. Obviously the specific material composition will in part determine the weight of the coin.

The viable alternatives with respect to the size of the one cent and two cent coins are limited in number. Table 5-1 presents the dimensions of existing U.S. denominations for comparison.

Table 5-2 contains four options for combinations of diameter and thickness for the one cent and two cent coins. Option 1 represents simply the existing mix of denominations; that is, maintaining a one cent coin of the current size with no two cent coin.

In option 2, the diameter and thickness of the one cent and two cent coins would both be the same as the current one cent coin. This option would necessitate that the material or configurational characteristics of the two denominations be distinct.

One means of discrimination from the one cent coin would be to engrave features on the two faces and by slight quarter-point edge indentions. This affords personal, but not necessarily mechanical, discrimination between the one and two cent coins. The primary advantages of similar sized coins would be convenience if the cent is eventually phased out in favor of the two cent coin and that legislation could be sought to declare the value of the cent to be two cents if eventually the metal value of the one cent exceeds its face value, thereby encouraging their release to circulation. However, these advantages must be balanced off against the disadvantages associated with manual processing 80 percent of the U.S. coinage.

For option 3, the present dimensions of the one cent coin are maintained, and the diameter of the two cent coin would be 20.13 mm, or halfway between the diameters of the current one cent coin and the nickel. For this option, the two cent coin would possess the same thickness as the one cent coin, and discrimination would be based on the diameter and/or material composition. Option 4 would differ from option 3 only in the thickness of the two cent coin. This option would

Table 5-1

Dimensions of Existing U.S. Coin Denominations

Denomination	Weight (gm)	Diameter (mm)	Thickness (mm)
10¢	2.268	17.91	1.35
1¢	3.11	19.05	1.57
5¢	5.00	21.21	1.98
25¢	5.67	24.26	1.70
50¢	11.34	30.61	2.18
$1.00	22.68	38.10	2.54

Table 5-2

Options for Dimensions of One Cent and Two Cent Coins
(In Millimeters)

Option	1	2	3	4
1¢ Diameter	19.05	19.05	19.05	19.05
1¢ Thickness	1.57	1.57	1.57	1.57
2¢ Diameter	---	19.05	20.13	20.13
2¢ Thickness	---	1.57	1.57	1.77

provide additional discrimination with the thickness of the two cent coin halfway between that of the one cent coin and that of the nickel. Other options involving a change in the size of the one cent coin, or a size for the two cent coin smaller than the current one cent size, were excluded from further consideration as less acceptable.

The determinants of the size of a coin denomination were considered and evaluated with respect to the following factors: the distinction from foreign coins; the preferences for size exhibited through the survey of the target groups of coin users; and the compatibility with existing equipment.

2.2.2 Foreign Coin Sizes

The preliminary selection of the options for sizes of the minor coin denominations must be considered with respect to their difference from foreign coins. To accomplish this, all world coinage diameters between 19.05 mm (the diameter of the current cent), and 21.21 mm (the diameter of the nickel) were recorded. These 155 coin denominations are listed in Table C-1 (in Appendix C). Fifty-one of the denominations are 20.0 mm exactly; only nine are between 20.0 mm and 20.5 mm. There are no coins of 20.13 mm diameter, although several are within 0.1 mm. The coins in this close tolerance are of sufficiently different thickness to enable discrimination, and none of them is composed of aluminum.

2.2.3 Survey Preferences

The surveyed target groups of coin users were specifically asked their preferences for the diameter, thickness, and weight of a two cent coin if it were introduced. The majority of all respondents indicated a strong preference for a diameter between that of the one cent coin and that of the nickel for a two cent coin, although 20.4 percent of the firms in the automatic merchandising industry did indicate a preference for a diameter similar to that of the one cent coin. One responding retail firm executive commented:

> "With the exception of the 10¢ coin - all other coins increase in value with its size and this would seem to me to be a logical step with the 2¢ coin."

Another retail firm commented with respect to all physical characteristics of the two cent coin:

> "If you insist on introducing a new coin, it should be distinctively different."

With respect to the thickness of a two cent coin, the responses were not so clearly defined. There was a marginal preference on the part of retail firms for a two cent coin with the same thickness as the one cent coin, rather than a thicker coin (44.0 percent versus 43.5 percent). More than half of the banks and automatic merchandising firms preferred the same thickness as the one cent coin, with approximatey thirty percent preferring a thicker coin.

The most preferred weight for a two cent coin was indicated to be similar to that of the one cent coin.

In summary, the preferences indicated through the survey for the size of a two cent coin are that its diameter be between those of the one cent coin and nickel, and its thickness and weight be similar to that of the one cent coin. That is, the distinction between the size of the one and two cent coins should be based on their difference in diameter.

2.2.4 Compatibility With Existing Equipment

The two cent coin, if configured any differently from the one cent coin in terms of its diameter, thickness, or weight, would be, by nature, incompatible with existing coin validating equipment. Coin mechanisms would have to be modified to handle the coin, whether to automatically reject it (as with the current one cent coin) or to accept it as a valid coin. Coin sorting, counting, and wrapping equipment could be modified to process this denomination. (i.e., initially the coin could be sorted manually, but this would be expensive in the long term).

If a two cent coin were the same size as the one cent coin, both human and machine discrimination would necessarily be based on characteristics other than size. That is, the two cent coin could not be distinguished from the one cent coin by mechanical coin processing equipment if the coins were the same size. The primary argument for identical sizes stems from the automatic rejection of the one cent coin by many vending

machines -- with identical sizes and material compositions, the two cent coin could also be automatically rejected. However a two cent coin of aluminum might not be rejected automatically, regardless of its size, due to its light weight.

2.2.5 Recommendation for Size

In order to discriminate between the currently minted one cent coin and a two cent, it is recommended that the size of a two cent coin, if introduced, be 20.13 mm in diameter and 1.77 mm in thickness (option 4 in Table 5-2). This is based on the preferences of coin users, the compatibility with existing equipment, and distinction from foreign coins.

2.3 Configuration

2.3.1 Introduction

The configuration of a coin is determined by its shape, and its surface or edge characteristics, including the engraving, and whether the edge is reeded or smooth. All the coins composing the current U.S. coinage system are round. The cent and nickel have smooth edges while the dime, quarter, half dollar and dollar coins have reeded edges. A new coin of a different configuration -- with scalloped shape, a hole in the center, or multi-sided, might enable greater human discrimination between the denominations. Such alternatives must be considered with respect to the preferences of coin users, and the compatibility with existing coin processing equipment.

2.3.2 Survey Preferences

The surveyed coin users were asked their preferences for the configuration of a two cent coin, particularly its shape and edge characteristics. Most respondents indicated a strong preference for a round two cent coin. Several reasons were cited by manufacturers of coin processing equipment:

"Any shape other than round or presence of holes could interfere with counting, sorting."

"Prefer the rounded shape. The rounded shape causes the least feeding and stacking problems."

"All coins should be manufactured with a solid round configuration. Other configurations can not be sorted on conventional equipment."

Although the response was less unanimous than for a round coin, the majority of respondents indicated a preference for a smooth-edged two cent coin:

"Prefer smooth edges on all coins. The reeded edge causes feeding problems in some of the coin systems we manufacture."

"All coins should be manufactured with a smooth edge with consistent thickness. Reeded edges do not process as smoothly on coin counting and sorting equipment."

2.3.3 Preferences of the Visually-Impaired

Consultants at RTI met with representatives of the North Carolina Division of Services of the Blind and with Mr. Durvard K. McDaniel of the American Council of the Blind in Washington, D.C. Representatives of the North Carolina Chapter and national headquarters of the National Federation of the Blind were contacted, as were representatives of the North Carolina Chapter of the American Council of the Blind. It is important that the design of a two cent coin permit discrimination by touch to visually-impaired persons. Such discrimination might be facilitated by distinctive engraving or raised edges. However, the easiest manner of distinguishing a new denomination sized between a cent and a nickel would be to mint the coin with a hole in the center.

2.3.4 Compatibility With Existing Equipment

The introduction of a two cent coin of the recommended size will be incompatible with existing coin processing equipment. While a reeded edge or a hole in the center of the coin would facilitate discrimination by touch, which is particularly important for the visually impaired, these characteristics would increase a two cent coin's incompatibility with existing equipment.

2.3.5 Recommendations for Configuration

Based on the discussed impacts, and to maximize compatibility with existing coinage, it is recommended that any two cent coin be round, have a smooth edge, and have distinct engraving that would allow ease of discrimination by touch. If a high degree of relief is not feasible, then a center hole will be necessary.

3.0 THE ONE DOLLAR COIN

3.1 Introduction

A more conveniently-sized one dollar coin, as recommended in the previous chapter, should be minted of cupronickel clad over copper. If it is reduced to close to the size of a quarter, the coin must also have distinctive characteristics to be easily identified visually, by tough, and mechanically. Also, unless the small dollar possesses additional unique characteristics, it could be counterfeited by a cut-down half dollar or by other accessible slugs. It is therefore imperative that the coin have highly distinctive discrimination characteristics. These characteristics include both size and configuration and will be discussed in turn.

3.2 Size Characteristics

3.2.1 Introduction

Coin diameter, thickness, and weight obviously affect both human and machine coin discrimination. The one dollar coin should be distinct in touch and appearance to insure that people can readily discern its denomination. From the standpoint of machine discrimination, particularly in the vending industry, the coin's size should not be duplicated by that of any world coin, especially if the foreign coin is of lower value. The diameter and thickness of the one dollar coin will determine its weight since the density of the material is fixed.

The diameter of the quarter is 24.26 mm, and the diameter of the half dollar is 30.61 mm (refer to Table 5-1). A "conveniently-sized" one dollar coin should obviously be smaller than the half dollar, since the half dollar circulates poorly and it should be larger than the quarter to facilitate discrimination.[1/]

In this section, several parameters relevant to the determination of the size of the one dollar coin are considered and evaluated: its distinction from world coinage; the preferences for size determined through the survey of the target groups of coin users; and compatibility with existing equipment.

3.2.2 Foreign Coin Sizes

The size of the one dollar coin should be different from that of any foreign coin, particularly those of lower value. In order to insure this, all world coins with diameters between 25.5 mm and 28.0 mm were considered in terms of their composition and thickness as well as their diameters. These world coins are included in Table C-2 (in Appendix C). There are 173 world coin denominations with diameters in this range. Twenty-four of these denominations are between 25.5 mm and 26.0 mm; thirty-four are exactly 26.0 mm; seventeen are between 26.0 mm and 27.0 mm; 45 are exactly 27.0 mm; 24 are between 27.0 mm and 28.0 mm; and 29 are exactly 28.0 mm. In order to conflict with the fewest foreign coin sizes, the one dollar coin should therefore be between 26.0 mm and 27.0 mm.

There are only two foreign denominations in this range, both at 26.5 mm: the 100 franc coin of Reunion, composed of pure nickel; and the 25 pesetas coin of Spain, composed of cupronickel. Although the Spanish coin is lower valued than one dollar, it could be rejected in vending machines by a material check and by an edge check.

3.2.3 Survey Preferences

When asked their preferences for the size of the one dollar coin which would be most useful for commercial transactions, a suprising

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[1/] As discussed in Chapter 3, a reduction in size was considered for both the half dollar and one dollar coins, however there is not a sufficient span of convenient sizes to allow the introduction of coins of two distinct sizes that could be easily discriminated.

number of the respondents chose the specifications for the one dollar coin as currently minted. Exhibits 5-1, 5-2, and 5-3 present the comparison of the preferences for these measures of the size of a one dollar coin by group.

As seen in Exhibit 5-1, the automatic merchandising industry and the manufacturers of equipment prefer a smaller one dollar coin with a diameter between those of the current quarter and half dollar coins. The number of respondents in the other groups preferrring the present diamater of the one dollar coin outweighed those preferring a smaller diamater.

Exhibit 5-2 presents the preferences for the thickness of a one dollar coin by group. More respondents prefer the present thickness of the one dollar coin to a thickness between that of the quarter and present one dollar coin. However, in the commercial banking, automatic merchandising, and coin equipment manufacturing industries, the preferences are marginal.

Respondents representing the automatic merchandising industry prefer that the weight of a one dollar coin be similar to that of the quarter. In the other groups, as presented in Exhibit 5-3, there is a slight preference for the weight of the existing dollar coin over the weight of the quarter.

The survey respondents were asked to identify the characteristics which they felt would make the one dollar coin more useful for commercial transactions. However, their responses generally are believed to more accurately reflect their attitudes toward a circulating dollar coin rather than their opinion of a more desirable configuration.

The dollar and half dollar coins clearly are too large, as demonstrated by the poor circulation of the half and the nonexistent circulation of the dollar coin. By selecting the present size of the dollar as most preferred, the businesses may be interpreted as saying that they presently do not handle the coin, and that the lack of a circulating dollar coin has not adversely affected their cash transactions. Further, if a new dollar coin does circulate, they may have to implement physical or procedural changes to accommodate it, and these changes are not desired.

Exhibit 5-1

PREFERRED DIAMETER OF A
$1.00 COIN

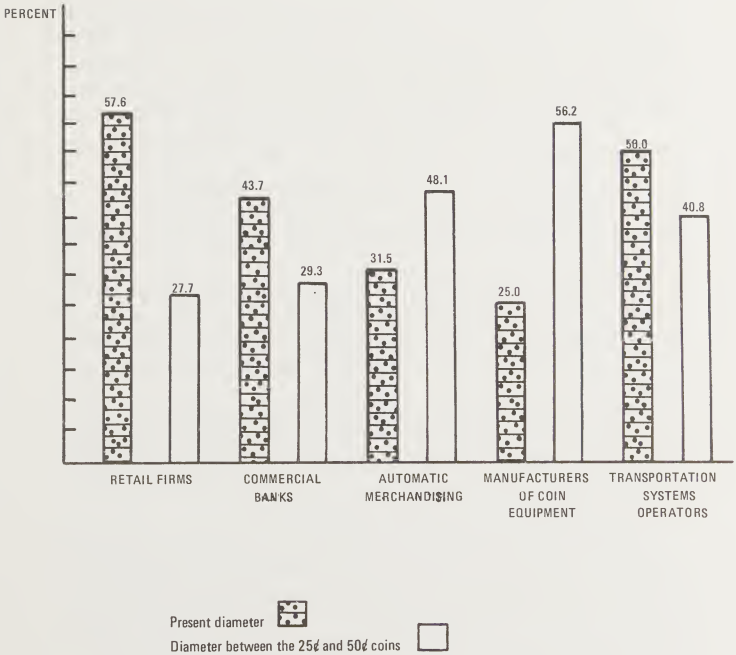


Exhibit 5-2

PREFERRED THICKNESS FOR A $1.00 COIN
BY GROUP.

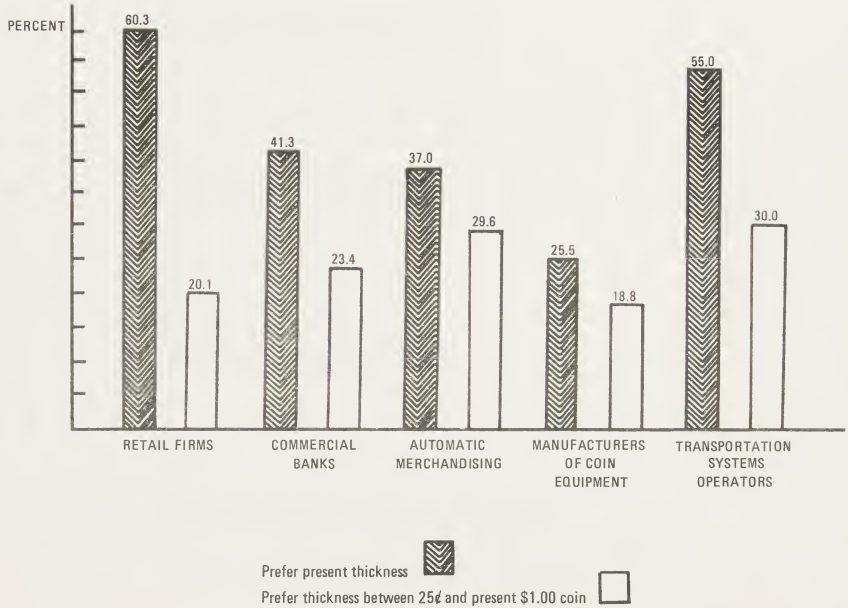
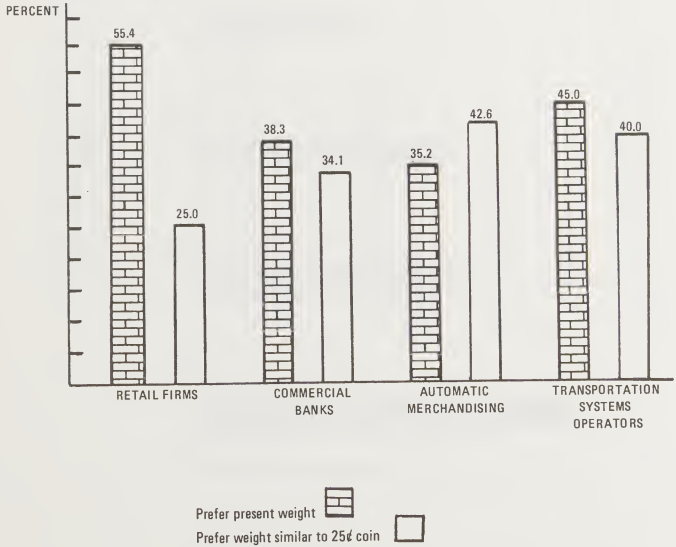


Exhibit 5-3

PREFERRED WEIGHT FOR A
$1.00 COIN BY GROUP



3.2.4 Compatibility With Existing Equipment

The introduction of a smaller one dollar coin of any size other than that of the current half dollar coin would precipitate the modification or replacement of existing coin processing equipment, unless manual handling was preferred. Consequently, a conveniently-sized dollar coin (different from the half dollar) would be incompatible with currently used coin processing and validating equipment.

To insure that those affected by a change would have a significant input in deciding the characteristics of a smaller dollar coin, the U.S. Mint prepared prototypes of this coin that differed in size, configuration and material composition, for experimental testing by the major manufacturers of coin equipment in the U.S. During the phases of design and testing of these prototypes, the U.S. Mint and RTI worked in conjunction with the National Automatic Merchandising Association (NAMA) to provide maximum input by the automatic merchandising industry. After completion of this experimental testing, RTI held a conference on June 22, 1976 that was attended by representatives of NAMA, coin equipment manufacturers, automatic merchandising firms, and the U.S. Bureau of the Mint.[1/] During this meeting, the size specifications for the one dollar coin were discussed. The consensus of those attending was that to insure the maximum compatibility with existing coin processing and validating equipment possible with such a change, the diameter of the coin should be 26.5 mm and the thickness should be 2.03 mm.

3.2.5 Recommendation for Size

In terms of uniqueness from foreign coins and compatibility with existing equipment it is recommended that the one dollar coin be 26.5 mm in diameter and 2.03 mm thick. Although this recommended size does not necessarily correspond with the survey preferences, those preferences reflected primarily the desire not to change the one dollar coin rather than any preferences for the coin given that change does occur.

[1/] A list of those attending this meeting is contained in Appendix E.

3.3 Configuration

3.3.1 Introduction

Shape, surface engraving, and edge characteristics determine a coin's configuration. Round coins compose the current U.S. coinage system. The dime, quarter, half dollar and one dollar coins have reeded edges, while the cent and the nickel have smooth edges. A new coin of unique configuration, e.g., with a scalloped or multi-sided shape, with a hole in the center, or with an indented edge, might enable greater human discrimination between the denominations. Such alternatives must be considered with respect to the preferences of coin users, and in terms of compatibility with existing coin processing equipment.

Given that the coin's composition would be cupronickel clad on copper, the smaller dollar should have a configuration particularly distinct from the current half dollar in order to avoid cut down half dollar coins substituting for the new dollar in vending mechanisms, or in automatic toll collection.

3.3.2 Survey Preferences

The surveyed coin users were asked their preferences for the configuration of a one dollar coin, particularly its shape and edge characteristics. The overwhelming majority of the respondents indicated a preference for a round one dollar coin. Similarly, the majority of respondents preferred a one dollar coin with a reeded edge.

3.3.3 Preferences of the Visually-Impaired

As previously discussed, consultants at RTI met with both North Carolina and national representatives of the visually-impaired. It is important to visually handicapped persons that a one dollar coin be configured to allow easy tactile discrimination, particularly so that it may be readily distinguished from the quarter. For this purpose, the coin could have raised or indented edges or distinctive engraving. Other more extreme configurations, such as a multi-sided coin would enable more rapid discrimination but are judged to be too incompatible with existing U.S. coinage.

3.3.4 Compatibility With Existing Equipment

The introduction of a one dollar coin smaller than both the present coin and the half dollar coin entails modification and/or replacement of coin processing and handling equipment unless the coin is to be processed manually. However, the configuration of the coin will determine the extent of the modifications required. Originally, an eleven-side coin was considered as an alternative configuration since it is attractive and would be difficult to counterfeit. The Mint prepared blank-faced prototypes that were distributed to manufactureres of coin acceptors, counting, and sorting equipment. After extensive experimental testing, the manufacturers of coin equipment indicated that an eleven-sided coin was not acceptable since it was not amenable to sensitive mechanical discrimination.

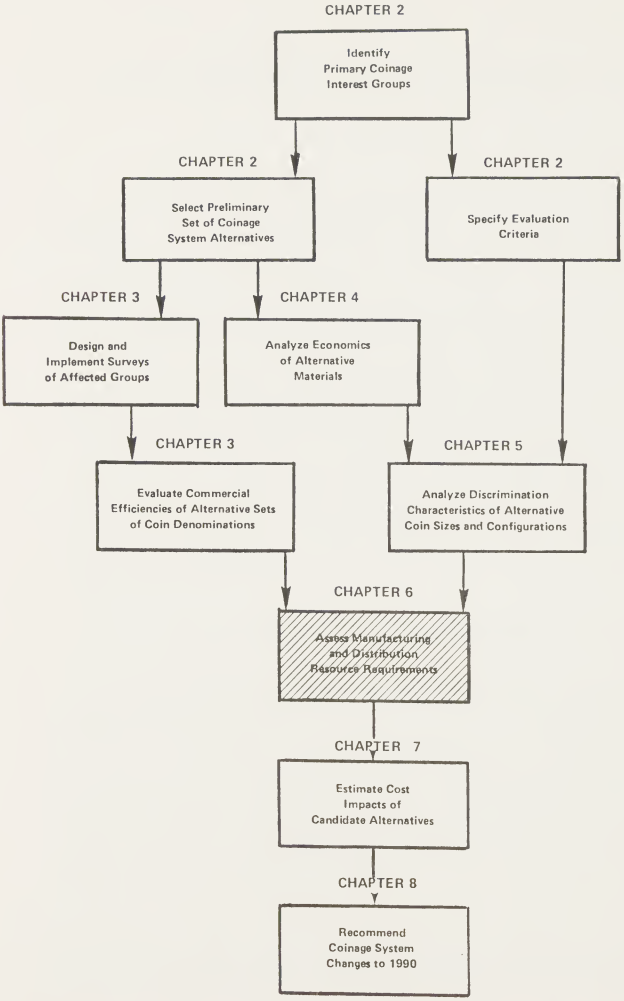
Several factors cause this lack of security: wider tolerances would be required in the diameter gaging mechanism due to the spread between the maximum and minimum diameters; a rolling multi-sided coin has an inconsistent trajectory in eddy current slug detector mechanisms; and the coin would not have reeded edges. The coin would also have a tendency to stand on its edge so that additional coins immediately inserted after it could prevent the first coin from falling flat, perhaps causing jams. For these reasons, the eleven-sided configuration was rejected as an alternative for the one dollar coin.

Since the coin is recommended to be smaller than the half dollar, yet of the same material, it is imperative that it be readily distinguishable from the half dollar by its configuration. This distinction would be particularly important for vending mechanisms; otherwise, a cut-down half dollar coin could substitute for the one dollar coin in vending purchases. Manners with which to facilitate this distinction were discussed at RTI's June 22 meeting and include minting the coin with maximum offsets in the surface, or with an indented edge. No specific alternative was decided then, and the Mint agreed to conduct experiments with several alternative configurations.

3.3.5 Recommendations for Configurations

It is recommended that the one dollar coin be round, and possess some additional configurational characteristics that would not only facilitate discrimination from a cut-down half dollar in vending mechanisms, but would allow greater tactile discrimination for the visually impaired. Whether the edges should be reeded or not would depend on the actual configuration. It is beyond the scope of this report to recommend more specifically the configuration of the coin. Additional experiments should be performed with these alternative configurations in order to discern the relative economies or diseconomies of either these or similar configurations.

Above all, since the initial success of a small dollar coin in circulation will depend almost wholly on its utility in automatic merchandising, protection from slugging must be assumed by precise discrimination characteristics of the coin without forfeiting any of the aesthetic qualities expected of a high valued coin.


CHAPTER 2
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CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 6

Manufacturing Resource Requirements for the Candidate Alternatives to the Present Coinage System

1.0 INTRODUCTION

The annual demand for coins of each denomination, configuration, and material composition determines the quantity and type of manufacturing and distribution resources that will be required to 1990. This chapter contains projections of the annual coin requirements for each of the candidate alternatives; including the introduction of an aluminum cent coin to replace the copper cent, the introduction of an aluminum or brass two cent coin to cocirculate with the copper cent, and the elimination of the one cent denomination. Additionally, the types and magnitudes of changes in production resource requirements likely with the introduction of a more conveniently sized one dollar coin are discussed.

Given the technological requirements for manufacturing the candidate alternatives, the facility and equipment needs to 1990 are estimated. The total requirements for coins and for manufacturing resources under the alternative scenarios are then compared with those estimated for the present coinage system.

2.0 FORECASTS OF COIN REQUIREMENTS

The annual coin requirements to 1990 for the present set of coin denominations were forecast using the intermediate projections reported in Phase I of this study.[1/] From those forecasts as well as estimates of future attrition rates, the stock of cent coins in circulation was projected to 1990. The forecasts of coin requirements for the candidate alternatives were then estimated, based on the assumption that the final stock of coins in circulation would be equivalent to the annual stock calculated for the present coinage set.

[1/] See Chapter 2, "Forecasting Coin Requirements to 1990" in A Comprehensive Review of U.S. Coinage Requirements to the Year 1990, Phase I: Current Denominations and Alloys.

2.1 Review of Present System Projections

During Phase I of this study, coin requirements for the present coinage set, by denomination, were projected to 1990. After examining the relationships between annual net payout, by denomination, and economic, demographic and temporal variables, the mathematical models providing the best estimates of future coin requirements were selected. The equations and estimated values listed in Table 6-1 through 6-3 constitute the range of estimates of net payout for each coin denomination.

The baseline projections constitute the most conservative estimates of the future trend in coin requirements (Table 6-1), setting a lower limit on annual coin demand expected to 1990. Although demand is projected to increase annually, the underlying assumption for the baseline forecasts is that the rate of growth will decline in the future. The baseline projections forecast that coin requirements will double from 1975 to 1990 for each denomination except cents, which are anticipated to increase by 136 percent. The cent, which constituted 82.2 percent of total coin requirements in 1975, is projected to comprise 85.2 percent of the 26.2 billion coin net payout in 1990. Overall the net payout is projected to increase by approximately one billion coins per year during the period.

The intermediate projections of annual coin requirements by denominations shown in Table 6-2 differ from the baseline projections by the cent equation. With the intermediate projections the cent requirements are estimated to increase by 300 percent from 1975 to 1990 when they will constitute 91 percent of the total requirements of 41.5 billion coins per year.

The ceiling projections of annual coin requirements shown in Table 6-3 provide a maximum reasonable estimate of coin requirements based upon trend projections. The primary assumption underlying these projections of coin requirements is that the annual demand will increase at a constant rate over time: 11.7 percent per year for cents, 9.2 percent per year for dimes, and 12.2 percent per year for quarters. With these rates of increase in coin demand, the annual cent demand will grow by 474 percent from 1975 to 1990. Total coin requirements will increase by 462 percent to 64.4 billion coins per year in 1990.

Table 6-1

Baseline Projections of Annual Coin Requirements by Denomination
(in billions of coins)

Year	Cent	Nickel	Dime	Quarter	Half	Dollar	Total
1975 (Actual)	9.422	.549	.785	.484	.176	.050	11.466
1977	9.889	0.700	0.954	0.589	0.217	0.068	12.417
1978	10.657	0.727	0.991	0.615	0.227	0.072	13.289
1979	11.456	0.753	1.029	0.640	0.237	0.076	14.191
1980	12.287	0.780	1.066	0.666	0.248	0.080	15.127
1985	16.910	0.912	1.254	0.795	0.298	0.100	20.269
1990	22.317	1.045	1.442	0.923	0.349	0.120	26.196

Table 6-2

Intermediate Projections of Annual Coin Requirements by Denomination
(in billions of coins)

Year	Cent	Nickel	Dime	Quarter	Half	Dollar	Total
1975 (Actual)	9.422	.549	.785	.484	.176	.050	11.466
1977	11.427	0.700	0.954	0.589	0.217	0.068	13.955
1978	12.706	0.727	0.991	0.615	0.227	0.072	15.338
1979	14.091	0.753	1.029	0.640	0.237	0.076	16.826
1980	15.587	0.780	1.066	0.666	0.248	0.080	18.427
1985	24.877	0.912	1.254	0.795	0.298	0.100	28.236
1990	37.576	1.045	1.442	0.923	0.349	0.120	41.455

Table 6-3

Ceiling Projections of Annual Coin Requirements by Denomination
(in billions of coins)

Year	Cent	Nickel	Dime	Quarter	Half	Dollar	Total
1975 (Actual)	9.422	.549	.785	.484	.176	.050	11.466
1977	11.874	0.809	1.210	0.826	0.248	0.068	15.035
1978	13.342	0.863	1.326	0.932	0.268	0.072	16.803
1979	14.992	0.919	1.453	1.053	0.289	0.076	18.782
1980	16.847	0.978	1.593	1.189	0.311	0.080	20.998
1985	30.179	1.302	2.518	2.182	0.432	0.100	36.713
1990	54.063	1.682	3.981	4.006	0.573	0.120	64.425

Baseline

$P = 862 + 15.672T^2$
$N = 61.9 + 26.6T$
$D = 55.0 + 37.45T$
$Q = -29.7 + 25.75T$
$H = -25.3 + 10.1T$
$\$ = -28 + 4T$

Intermediate

$P = 1612 + 0.71T^3$
$N = 61.9 + 26.6T$
$D = 55.0 + 37.45T$
$Q = -29.7 + 25.75T$
$H = -25.3 + 10.1T$
$\$ = -28 + 4T$

Maximum

$LnP = 6.5837 + .1166T$
$N = 175.8 + 1.1T^2$
$LnD = 4.9 + .0916T$
$LnQ = 3.8 + 1215T$
$H = 12.2 + .41T^2$
$\$ = -28 + 4T$

Exhibit 6-1 illustrates the estimated total annual coin requirements for the baseline, intermediate, and ceiling projections. The projection chosen as the best estimate for facility planning purposes through 1990 is the sum of the intermediate projections for each denomination.

Facility planning based on the highest requirements anticipated (the ceiling projection) would dictate an accelerated rate of capacity expansion. This would have the greatest likelihood of producing excess capacity, which is costly because it requires capital expenditures before they are required.

Planning based on the most conservative estimate of future requirements (the baseline projections) will minimize the likelihood of having excess production capacity. Conversely, it maximizes the likelihood that coin shortages and inefficient utilization of resources will occur due to the unavailability of necessary capacity, because capacity expansion requires at least 5 years from the initial planning to become operational The Mint is familiar with this planning environment, because the projections of coin demand for 1985 which were made in 1962 and the projections for 1980 which were made in 1967 were both reached in 1975.[1/][2/]

2.2 Methodology for Forecasting Alternative Coin Requirements

The stock of coins in circulation in any given year is equal to the stock of the previous year plus additions minus withdrawals from the stock. Of all components of coin demand, only transactions demand adds to the stock of coins in circulation. Numismatic and speculative demand, and indirect hoarding are factors that reduce the quantity of coins in circulation. The net effect of the withdrawals is the annual attrition from the circulation stock of coins.

Estimates of the attrition rates for each denomination were calculated in 1973 from dates recorded for a sample of coins in the cash registers of Sears, Roebuck, and Company in November, 1973. In 1963, the

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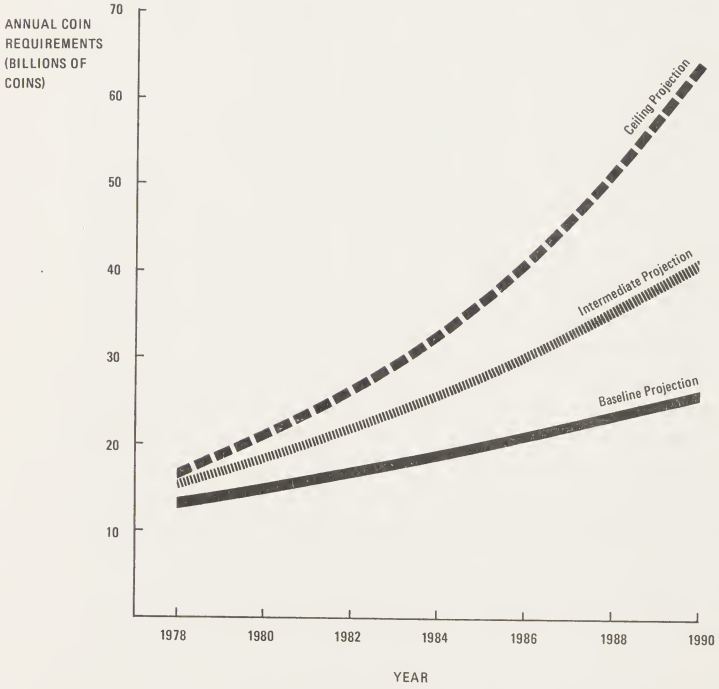
[1/] "Production Facilities for the United States Mint," A.D. Little, Inc. Final Report to the Director of the Bureau of the Budget, February 11, 1963, pp. 21-4, Table B-V.

[2/] "Coin in Circulation," George R. Morrison, Consultant to the Office of Planning and Program Evaluation, Office of the Secretary of the Treasury, June, 1967, pp. 43-56.

Exhibit 6-1

ALTERNATIVE PROJECTION OF TOTAL COIN REQUIREMENTS



attrition rate for each denomination, similarly based on the distribution of dates in a sample of coins, was calculated for the Mint Production Facilities Study.[1/2/] Respectively, the samples in the two studies indicated attrition rates for cents of 4.8 percent in 1962 and 13.0 percent in 1973. This equates to a 0.75 percent annual average increase in the attrition rate over the period.

For purposes of projecting the circulating stock of cent coins over the time period from 1975 to 1990, RTI assumed that the annual requirements for cent coins would follow the intermediate level projections of net payout. Although the attrition rate for cents historically has increased an average of .75 percent per year, a more conservative estimate of .50 percent per year was assumed for the future annual growth rate in cent attrition yielding an estimated 21.0 percent total cent attrition rate by 1990. The circulating stock of cent coins estimated at 35 billion in 1973 was used as the base stock figure for these calculations. Table 6-4 presents the computations for the annual estimates for the stock of cents. Based on the above stated assumptions, this stock increases from 35.0 billion in 1973 to 116.1 billion in 1990. These estimates provide the foundation for the projections of coins under the scenarios of coin production outlined for the implementation of the candidate alternatives.

To examine the sensitivity of the estimates to the assumption about the behavior of the attrition rate, the stock was projected under two alternative assumptions: first, that the attrition rate increases by 0.25 percent annually and second, that the attrition rate increases 0.75 percent rather than 0.5 percent annually. The projections with these alternative assumptions are also included in Table 6-4. Exhibited in the table, the assumption of a 0.25 percent per year increase in the attrition rate results in a circulating stock of 138.8 billion cent coins by 1990, or approximately 1.2 times the original projection. If the attrition rate increased 0.75 percent per year, the stock in 1990

1/ One Cent Coinage: A Summary of the 1973-1974 Treasury - Federal Reserve Committee Studies, Department of the Treasury, October 1974, p. 13.

2/ "Production Facilities for the United States Mint," Final Report to the Director of the Bureau of the Budget, Arthur D. Little, Inc., February 1960, p. 69.

Table 6-4

Projection of the Circulating Stock of Cent Coins Under Alternative Attrition Assumptions (coins in billions) 1/

Year	Annual Net Payout	Attrition Rate 3/	Stock of Cents 2/3/	Attrition Rate 4/	Stock of Cents	Attrition Rate 5/	Stock of Cents 5/
1973	6.665	.125	35.0	.125	35.0	.125	35.0
1974	8.595	.130	37.9	.128	38.0	.132	37.8
1975	9.422	.135	40.9	.130	41.3	.140	40.6
1976	8.4	.140	42.4	.132	43.1	.148	41.8
1977	11.4	.145	46.0	.136	47.2	.155	44.9
1978	12.7	.150	49.9	.138	51.6	.162	48.3
1979	14.1	.155	54.1	.140	56.5	.170	51.8
1980	15.6	.160	58.5	.142	61.9	.178	55.4
1981	17.2	.165	63.2	.145	67.6	.185	59.2
1982	18.9	.170	68.2	.148	73.7	.192	63.1
1983	20.8	.175	73.4	.150	80.3	.200	67.1
1984	22.8	.180	78.9	.152	87.4	.208	71.2
1985	24.9	.185	84.6	.155	94.9	.215	75.5
1986	27.1	.190	90.5	.158	102.8	.222	79.8
1987	29.5	.195	96.6	.160	111.1	.230	84.1
1988	32.1	.200	102.9	.162	120.0	.238	88.6
1989	34.7	.205	109.4	.165	129.2	.245	93.1
1990	37.6	.210	116.1	.168	138.8	.252	97.7

1/ 1973-1975 are actual figures; 1976 is 1976-1 actual, 1976.2-1976.4 are "MAX" Quarterly Cent Projections; and 1977-1990 are projected by "intermediate" level equation $C = 1612 + 0.71\ T^3$ (1954=1).

2/ $Stock_t = (Stock_{t-1} + Net\ Payout_t) \times (1 - Attrition\ Rate_t)$, where t = year.

3/ Assuming the attrition rate increases by .5 percent per year.

4/ Assuming the attrition rate increases by .25 percent per year.

5/ Assuming the attrition rate increases by .75 percent per year.

SOURCE: David H. Stuart, et. al., A Comprehensive Review of U.S. Coinage Requirements to the Year 1990, Phase I: Current Denominations and Alloys, Table 2-9, p. 2-34; Table 1-2, p. 1-11; and Table 2-5, p. 2-24.

would be 97.7 billion cents, roughly 85 percent of the original projections. These alternative projections indicate that by a 50 percent variation in the estimated growth in attrition produces a 20 percent variation in the stock of cents in circulation projected for 1990.

2.3 Forecasts of Coin Requirements With a Compositional Change to an Aluminum Cent Coin

A wide range of metals, alloys, and nonmetallic materials were investigated as alternatives to the copper cent. The materials analysis confirmed the findings of the Bureau of the Mint studies conducted in 1973 and 1974, that aluminum and copper clad on steel are the only two satisfactory compositions which are readily available and offer seigniorage protection to the year 1990. However, the annealing problems, the excessive hardness, and the minimal value of resultant scrap material rendered the copper clad on steel alternative unacceptable. Therefore, the only viable alternative material for the cent is aluminum, as the Bureau of the Mint concluded in 1973.

The most effective strategy to implement this alternative will be to terminate production of copper cents and initiate full production of aluminum at a designated conversion date. The transformation may be postponed to as late as 1980, when positive seigniorage on copper cents will likely cease. However, an unexpected increase in copper prices could necessitate a more immediate need to substitute aluminum for copper. Also, if the transition is made, it will be economically advantageous to make the substitution as soon as possible. January, 1978 was considered the earliest and most advantageous date for an orderly change.

With a compositional change of the cent to aluminum in 1978, copper cents would be rapidly withdrawn from circulation. In forecasting the coin requirements for aluminum cents, it was conservatively assumed that this withdrawal would occur during a six year period at rates of 25 percent of the stock for three years, 50 percent of the remaining stock for the two following years, and that by 1983, the remaining copper cents would be completely withdrawn. Consequently, during the first six years after the change, the production requirements for aluminum coins would include replacement for the copper cents withdrawn, resulting in higher rates of coin production during this period.

Table 6-5

Projected Cent Production Requirements With An Aluminum Cent
(Coins in Billions)

Year	Attrition Rate of Copper Cents	Stock of Copper Cents	Stock of Aluminum Cents	Base Production Requirements[1/]	Alternative Production Requirements[2/]
1978	.25	34.5	15.4	18.1	18.1
1979	.25	25.9	28.2	18.0	18.2
1980	.25	19.4	39.1	18.3	18.9
1981	.50	9.7	53.5	25.0	26.1
1982	.50	4.9	63.3	22.8	24.6
1983	1.00	0	73.4	25.7	28.4
1984			78.9	22.8	26.5
1985			84.6	24.9	29.6
1986			90.5	27.1	32.9
1987			96.6	29.5	36.6
1988			102.9	32.0	40.7
1989			109.4	34.7	44.8
1990			116.1	37.6	49.6

[1/] With attrition rate at 15 percent in 1978 increasing 0.5 percent annually.

[2/] With attrition rate at 15 percent in 1978 increasing 1.0 percent annually.

Postponing implementation to 1978 will allow time to manufacture and accumulate cent inventories to compensate for immediate hoarding of copper cents. In addition, expanding coin production capacity will place severe pressures on the Mint resources.

Table 6-5 contains the production forecasts for aluminum cents under two alternative assumptions about the attrition rate. The first of these projections assumes that an attrition rate of 15 percent in 1978 will increase 0.5 percent annually; equivalent to the original projections for the copper cent. However, the attrition rate for the aluminum cent may increase more rapidly than is projected for the copper cent, particularly if its light weight and appearance heighten the public perception of the cent as a "worthless" coin. Accordingly, a second set of projections, assuming an attrition rate of 15 percent in 1978 that increases one percent annually, is provided to illustrate the potential magnitudes of the impact.

2.4 Forecasts of Coin Requirements With The Introduction of a Two Cent Coin

Arbitrary restriction of one cent coin production could create an undesirable shortage of coins for conducting commercial transactions. Introduction of a two cent coin will provide a means for the Bureau of the Mint to curtail cent production by offering a substitute denomination. For this alternative the benefits of reduced facility requirements and the possibility of a less abrupt transition to the eventual elimination of the cent must be balanced against the disadvantages of a more complex coinage system.

As with the cent, several metals and alloys are feasible candidates for the two cent coin. Copper clad on steel, several copper-zinc alloys and aluminum all received serious consideration as candidate materials. Copper clad on steel subsequently was rejected for the same reasons outlined in the cent analysis. Brass (70 percent copper, 30 percent zinc) was selected as a primary candidate due to the favorable response to the questionnaires, its distinctive color, and desirable material characteristics. Aluminum also was selected as a two cent candidate for the same reasons outlined for its selection as an alternative cent material.

Cocirculating with the two cent coin, the composition of the cent should remain copper, due to its recommended limited near term production levels and eventual elimination. Changing the cent material simultaneously with introduction of a two cent coin would compound the complexities of the change and stimulate additional difficulties for this option.

The fundamental justification for introducing a two cent coin is to minimize total coin requirements by substituting two cent coins for cents as extensively as possible in circulation. The following strategy is recommended during the transition period of two cent introduction on the basis of historical precedences of coin hoarding.

Two cent coin payout would begin in 1978, and simultaneously one cent coin production would be curtailed to four billion coins per year. Termination of all cent production even for a short period would be perceived as signalling the elimination of the cent, leading to extensive cent hoarding which would defeat the primary purpose of the two cent introduction. Production of four billion cents per year was estimated to be a sufficient level to discourage excessive numismatic interest or speculative cent hoarding. However, continuing cent production at four billion coins per year will lead to an accelerated depletion of the stock of cent coins in circulation and forced substitution of the two cent denomination for cents in transactions. Assuming a 75 percent rate of efficiency in substitution, a balanced mix of one and two cent coins would be achieved by 1989.

For purposes of this analysis a balanced increase in one and two cent production is assumed beyond 1989. However, forced substitution of the two for the one cent coin will lead to some pricing and transactions adjustments equivalent to those which would be caused by elimination of the cent.

The two cent coin is assumed to have a lower attrition rate than the one cent coin due to its higher value: increasing 0.25 percent annually from 10.25 percent in 1978. Table 6-6 presents the projected annual production requirements for both one and two cent coins.

Table 6-6

Projected Coin Requirements With the Addition of a Two Cent Coin 1/
(Coins in Billions)

Year	Cent Production	Cent Attrition Rate	Cent Stock	Two Cent Production	Two Cent Attrition Rate	Two Cent Stock	Total One and Two Cent Production
1978	4.0	.150	42.5	6.5 2/	.102	4.9	10.5
1979	4.0	.155	39.3	7.2 2/	.105	9.9	11.2
1980	4.0	.160	36.4	6.6	.108	14.7	10.6
1981	4.0	.165	33.7	7.4	.110	19.7	11.4
1982	4.0	.170	31.3	8.0	.112	24.6	12.0
1983	4.0	.175	29.1	8.7	.115	29.5	12.7
1984	4.0	.180	27.2	9.6	.118	34.5	15.6
1985	4.0	.185	25.4	10.4	.120	39.5	14.4
1986	4.0	.190	23.8	11.2	.122	44.5	15.2
1987	4.0	.195	22.3	12.1	.125	49.5	10.1
1988	4.0	.200	21.1	13.0	.128	54.5	17.0
1989	6.4	.205	21.9	12.5	.130	58.3	18.9
1990	7.5	.210	23.2	13.0	.132	61.9	20.5

1/ $Stock_t = (Stock_{t-1} + Annual\ Production_t) \times (1 - Attrition\ Rate_t)$, where t = year.

2/ Includes 1 billion coins for numismatists.

Overall, introduction of a two cent coin is a strategy which delays the eventual elimination of the cent coin and provides the means for a less abrupt transition than simply eliminating the cent. Production requirements would be periodically reviewed, and when considered most acceptable, cent production could be terminated altogether. The initial substitution of two cent coins for cents would stimulate some pricing and packaging merchandising accommodations. Further accommodations would then be necessary to adjust to a two cent minimum denomination, but the adjustments would be less severe than would be necessary to accommodate change from a one cent to a five cent minimum denomination.

2.5 Production Requirements With The Elimination of the Cent Denomination

A viable solution to the cent dilemma is to terminate production of the cent denomination altogether. This alternative requires Congressional approval and may be implemented with one of several degrees of fore-warning to the public. Abrupt termination of cent production could substantially disrupt transaction activity and lead to overwhelming negative reaction from the public. On this basis and to facilitate an orderly reduction in Mint workforce and resources, a strategy to request Congressional approval to eliminate the cent at least one year in advance of the termination date is recommended. This phaseout strategy will allow businesses a more orderly and efficient adjustment in pricing, packaging, and transactions policies. Also, the public can be more effectively educated to the implications of eliminating the cent during the adjustment period.

Public acknowledgement that elimination of the cent is impending will most likely be accompanied by widespread cent hoarding. Businesses and banks will attempt to accumulate additional cent inventories in anticipation of forthcoming cent shortages, and many individuals will consciously save cents for their perceived numismatic value.

To partially compensate for the immediate withdrawal of large quantities of cents from the circulating pool, the Mint should accumulate additional cent inventory beforehand for release to banks. (An immediate 10 percent reduction in the circulating pool would equal 4.6 billion cents.)

Total production requirements will not decrease by the quantity of cent production eliminated. Elimination of the cent will induce increased demand for nickels and dimes in commercial transactions, particularly since the nickel would become the base unit for cash transactions. The magnitude of the increased nickel and dime requirements is very uncertain.

Table 6-7 outlines one possible scenario of coin production requirements, in which the requirements for nickels and dimes double. In this scenario, six billion cent coins are produced in 1978. The circulating pool of cents is expected to be depleted by 1983, with attrition occurring at rates of 25 percent for three years and 50 percent for the two following years. The projected production of nickels and dimes is twice that estimated with the intermediate equations.

2.6 Comparison of the Projections of Coin Requirements for the Candidate Alternatives to the Copper Cent

Comparison of the forecasts of coin requirements to 1990 for the present set of coin denominations and for the three alternative options are shown in Table 6-8 and Table 6-9.

Assuming no changes in coin denominations or alloys (i.e., maintaining the copper cent), cent requirements are projected to increase from 12.7 billion cents in 1978 to 37.6 billion coins in 1990; and total coin requirements will increase by 90 percent.

Replacement of the present cent with an aluminum coin will precipitate the accelerated withdrawal of copper cents. Thus, approximately 28.6 billion more aluminum cents must be manufactured during the first six years than would be required with the present cent.

The RTI projections assumed a six year withdrawal period for copper cents and an attrition rate for aluminum cents equivalent to that estimated for the copper cent. Both assumptions lead to conservative projections of aluminum cents. If copper cents are withdrawn more rapidly or if the attrition rate for aluminum cents is greater than estimated, which is very possible due to the increased public perception of worthlessness associated with an aluminum cent, the annual requirements for aluminum cents will exceed the projections.

Table 6-7

Projected Coin Requirements With the Elimination of the Cent
(coins in billions)

Year	Cent Production	Cent Attrition	Cent Stock	Nickel Production[1/]	Dime Production[2/]
1978	6.0	.25	39.0	1.5	2.0
1979	0	.25	29.2	1.5	2.1
1980	0	.25	21.9	1.6	2.1
1981	0	.50	11.0	1.6	2.2
1982	0	.50	5.5	1.7	2.3
1983	0	1.00	0	1.7	2.4
1984	0	-	-	1.8	2.4
1985	0	-	-	1.8	2.5
1986	0	-	-	1.9	2.6
1987	0	-	-	1.9	2.7
1988	0	-	-	2.0	2.7
1989	0	-	-	2.0	2.8
1990	0	-	-	2.1	2.9

[1/] 2 x (61.9 + 26.6T), where T = year (1954 = 1).

[2/] 2 x (55.0 + 37.45T), where T = year (1954 = 1).

Table 6-8

Projected Annual Coin Requirements
(Billions of Coins)

Year	Present Mix		Alternative 1: Aluminum Cent		Alternative 2: 2 Cent Introduction			Alternative 3: Cent Eliminated	
	Cent	Total	Cent	Total	Cent	2 Cent	Total	Cent	Total
1978	12.7	15.3	18.1	20.7	4.0	6.5	13.1	6.0	10.3
1979	14.1	16.8	18.0	20.7	4.0	7.2	13.9	0	4.5
1980	15.6	18.4	18.3	21.1	4.0	6.6	13.4	0	4.6
1981	17.2	20.1	25.0	27.9	4.0	7.4	14.3	0	4.8
1982	18.9	21.9	22.8	25.8	4.0	8.0	15.0	0	5.0
1983	20.8	24.0	25.7	28.9	4.0	8.7	15.9	0	5.2
1984	22.8	26.1	22.8	26.1	4.0	9.6	16.9	0	5.4
1985	24.9	28.3	24.9	28.3	4.0	10.4	17.8	0	5.6
1986	27.1	30.6	27.1	30.6	4.0	11.2	18.7	0	5.7
1987	29.5	33.1	29.5	33.1	4.0	12.1	19.7	0	5.9
1988	32.1	35.8	32.1	35.8	4.0	13.0	20.7	0	6.1
1989	34.7	38.5	34.7	38.5	6.4	12.5	22.7	0	6.1
1990	37.6	41.5	37.6	41.5	7.5	13.0	24.4	0	6.3
TOTAL	308.0	350.4	336.5	378.9	57.9	126.2	226.5	6.0	75.5

Table 6-9

Difference Between the Present System and the Candidate Alternatives in Total Projected Coin Requirements
(Billions of Coins)

Year	Present System Total Coin Requirements	Additional Coins Required		
		Alternative 1: Aluminum Cent	Alternative 2: 2 Cent Intro.	Alternative 3: Cent Eliminated
1978	15.3	5.4	-2.2	-5.0
1979	16.8	3.9	-2.9	-12.3
1980	18.4	2.7	-5.0	-13.8
1981	20.1	7.8	-5.8	-15.3
1982	21.9	3.9	-6.9	-16.9
1983	24.0	4.9	-8.1	-18.8
1984	26.1	0	-9.2	-20.7
1985	28.3	0	-10.5	-22.7
1986	30.6	0	-11.9	-24.9
1987	33.1	0	-13.4	-27.2
1988	35.8	0	-15.1	-29.7
1989	38.5	0	-15.8	-32.4
1990	41.6	0	-17.1	-35.2
TOTAL	350.4	28.6	-123.9	-274.7

Introduction of a two cent coin in 1978 to cocirculate with the present cent coin is projected to reduce the total coin requirements to 1990. This reduction is due to the incomplete substitution effect of two cent coins for cents in circulation, and assumes that cent coins will continue to be manufactured at a rate of 4 billion per year through 1988. With the two cent coin the annual requirements will be reduced by five billion coins per year by 1980, by 10.5 billion coins per year by 1985, and by 17.1 billion coins per year by 1990. In effect, introducing a two cent coin results in a six year deferral in the level of total coin requirements.

The final alternative option is the elimination of the cent denomination. As Table 6-8 illustrates the primary assumption for implementation of this option is that total cent requirements would be met in 1977, approximately one-half the normal cent requirements for 1978 would be manufactured, and no cent coins would be manufactured thereafter. If the cent denomination is eliminated, the total annual coin requirements by 1990 will be approximately 6.3 billion coins, or one-half the current requirements for the present U.S. coinage system. The net reduction in total coin requirements will not be equal to the cent requirements projected for the present system. Elimination of the cent will induce additional demands for nickels and dimes for use in commercial transactions, but this additional demand will be insignificant in comparison with the cent production which is eliminated, as Table 6-9 illustrates.

2.7 Production Requirements With a More-Conveniently-Sized One Dollar Coin

The transition to a conveniently-sized one dollar coin will have a minor impact relative to the implications for production requirements induced by the alternatives to the copper cent. The alternative one dollar coin would be sized between the current quarter and half dollar. Consequently, the production requirements for the new coin would most likely fall within the range of the projections for the quarter and the half dollar coins, rather than be equivalent to the projected requirements for the current one dollar coin. Table 6-10 presents the projections for the quarter, the half dollar, and the current dollar coins,

Table 6-10

Projected Annual Coin Requirements With A Conveniently Sized One Dollar Coin
(Billions of Coins)

Year	Quarter[1/]	Half Dollar[2/]	Current One Dollar[3/]	Alternative One Dollar
1978	0.62	0.23	0.07	1.00 [4/]
1979	0.64	0.24	0.08	0.44
1980	0.67	0.25	0.08	0.46
1981	0.69	0.26	0.08	0.47
1982	0.72	0.27	0.09	0.49
1983	0.74	0.28	0.09	0.51
1984	0.77	0.29	0.10	0.53
1985	0.80	0.30	0.10	0.55
1986	0.82	0.31	0.10	0.56
1987	0.85	0.32	0.10	0.58
1988	0.87	0.33	0.11	0.60
1989	0.90	0.34	0.12	0.62
1990	0.92	0.35	0.14	0.64

[1/] Quarters = -29.7 + 25.75T

[2/] Half Dollars = -25.3 + 10.1T

[3/] Dollars = -28 + 4T

[4/] Initial production to fill the distribution pipeline.

based on the intermediate projection equations for these denominations. The projections for the alternative dollar coin included in the table are halfway between those for the quarter and half dollar. During the first year after the introduction of the coin, the Mint should produce one billion coins for distribution.

Table 6-11 contains a comparison of the total coin requirements for the present coinage system, excluding the cent; the additional requirements if the new dollar coin is introduced without eliminating the half dollar coin; and the resulting additional requirements when the half dollar is discontinued. The additional requirements with the introduction of the smaller one dollar coin and the discontinuance of the half dollar coin equal only 2.26 billion coins over the entire 13 year period.

A direct correspondence does not exist between the annual coin requirements projected for the present mix and the alternative coinage sets and the resource requirements for manufacturing those coins. The manufacturing process requirements differ depending upon the material composition and size of the coins as well as the quantity demanded. In the following section the implications for manufacturing resource requirements for the candidate alternatives are discussed.

3.0 IMPLICATIONS FOR MANUFACTURING RESOURCE REQUIREMENTS OF THE CANDIDATE ALTERNATIVES

The primary function of the Bureau of the Mint is to manufacture and distribute the six currently-minted coin denominations to the 37 Federal Reserve Banks and branches for commercial dissemination. In addition the Mint refines, processes, and stores gold and silver bullion; manufacturers and sells proof and uncirculated coin sets, commemorative medals, and other items of numismatic interest; manufactures foreign coinage when excess production capacity is available; and manufactures ingots, coin strip, dies, coin bags, and other products associated with commercial coin production. This section focuses on the commercial coinage requirements and the affect of the candidate alternatives for those requirements.

Table 6-11

Difference in Total Coin Requirements With the Alternative One Dollar Coin 1/
(Billions of Coins)

Year	Present System Requirements 1/	Additional Coin Requirements	
		With Alternative One Dollar Coin	With New One Dollar Coin and Elimination of Half Dollar
1978	2.6	0.93	0.70
1979	2.7	0.36	0.12
1980	2.8	0.38	0.13
1981	2.9	0.39	0.13
1982	3.0	0.40	0.13
1983	3.2	0.42	0.14
1984	3.3	0.43	0.14
1985	3.4	0.45	0.15
1986	3.5	0.46	0.15
1987	3.6	0.48	0.16
1988	3.7	0.49	0.15
1989	3.8	0.50	0.16
1990	3.9	0.50	0.15
TOTAL	42.4	5.74	2.26

1/ Excluding cent requirements.

3.1 The Coin Production Process

The production of coins involves three primary transformation processes: the conversion of metals and alloys into coin strip; punch cutting of round coin blanks from the strip; and forming of blanks into coins. The Bureau of the Mint possesses sole authority to engage in the final coining process. However, commercial vendors may share in the intermediate production processes. Currently, the Mint purchases a minor portion of its coin blanks and a major portion of its coin strip from private companies. The raw metal necessary for coin production is purchased by the Mint from General Services Administration stockpiles or on the open metals market.

The complete sequence of manufacturing processes for current cent and nickel production consists of: makeup of the base metals in the correct proportion, melting the metals and casting the resulting alloy into ingots, rolling the ingots into coin strip, and forming blanks from the strip. To form the strip for dimes, quarters, half dollars and dollars, coils of cupronickel strip are annealed and cleaned and then roll-bonded to a copper core. Otherwise the sequences are similar. After blanking, coin blanks are riddled (passes over a vibrating mesh to check the diameter), annealed and cleaned, upset (the edges are raised), stamped as coins, weighed, counted and bagged, and then stored for shipment.

Since the Bureau of the Mint may rely on commercial producers for intermediate materials requirements, it may consider more flexible capacity expansion and additional strategies than commitment to fully integrated production would allow. As long as the Mint maintains sufficient coin stamping capacity to satisfy coin requirements, trade-offs between Mint capital investment costs and intermediate product purchase costs may be incorporated into the facility planning decisions.

3.2 Current Manufacturing Resources and Capacity

Each of the Mint facilities possesses different production capabilities and capacities. The Mint at Philadelphia, Pennsylvania engages in each of the manufacturing processes for coins as well as other peripheral

activities. Its planned strip production in FY 1977 is for 13.8 million pounds of clad strip, 7.8 million pounds of cupronickel strip, and 9.5 million pounds of penny bronze strip: sufficient strip to produce 2.6 billion coins.

The Mint at Denver, Colorado has terminated strip production and its sole function currently is to manufacture coin from commercially supplied strip. The potential production capacity of the Denver Mint by the end of FY 1977 will be 8.5 billion coins annually with the stamping process limiting capacity, and an active storage capacity of 1.2 billion coins. However, an 8.5 billion coin annual production rate would necessitate intensive utilization of cramped space, compounding existing materials handling and work flow inefficiencies and to placing greater reliance on the Butler buildings and other space external to the Mint building for storage of materials and finished coin.

The U.S. Bullion Depository at West Point, New York contains 23 secured storage compartments, each with approximately 900 square feet of floor space. While primarily used for bullion and coin storage, the facility has the necessary equipment to manufacture cents from blanks. The current capacity of the U.S. Bullion Depository has been estimated to be 1.5 billion cents per year.

The San Francisco Assay Office is the remaining facility with a capability for coin production. However, its limited capacity is dedicated to numismatic production, although it was used for limited cent and dime production during the 1973-74 cent shortage. Although its potential short-term production capabilities are recognized, the SFAO has been excluded from the inventory of Mint production capacity.

An estimate of the total Mint coin production capacity for existing plus planned installations of equipment is shown in Table 6-12. The total system capacity is 18.25 billion coins per year, with Philadelphia and Denver capable of producing 8.7 and 8.5 billion coins respectively, and the West Point Bullion Depository producing 1.5 billion cents from blanks manufactured elsewhere. Obviously, the total coin manufacturing capacity at Philadelphia and Denver is contingent upon the mix of coins produced, and the capacity estimates assume they both produce a proportional mix of coins.

Table 6-12

Mint Production Capacity
(Millions of Coins)

Denomination	Denver	Philadelphia	West Point	Total
Cent	6,990	7,140	1,500	15,630
Nickel	430	440		870
Dime	510	520		1,030
Quarter	430	440		870
Half-Dollar	85	90		175
Dollar	85	90		175
TOTAL	8,530	8,720	1,500	18,750

3.3 Manufacturing Requirements for the Candidate Alternatives

Given the existing Mint capacity and the technological requirements for manufacturing the candidate alternatives, the facility requirements for each alternative can be determined. Table 6-13 summarizes total manufacturing equipment available, and the estimated equipment requirements for each coin denomination except cents projected to 1990. The numbers of remaining equipment available to produce one or two cent coins are contained in Table 6-14. These estimates are based on the manufacturing coefficients of each process and machine type for each of the six currently minted coin denominations.[1/] The manufacturing requirements for each of the candidate alternatives are presented in Table 6-15. These projections are based on the projected numbers of coins required with each alternative.

3.3.1 Requirements With a Compositional Change in the Cent to Aluminum

The manufacturing process requirements for aluminum cents would differ substantially from those for copper cents. No annealing is required for aluminum coin blanks, and while the blanking press requirements are equivalent for copper and aluminum cents, approximately five percent greater stamping press capacity is required for aluminum due to the estimated reduction in die life which will increase machine downtime.

Changing the material composition of the cent to aluminum would significantly shift the manufacturing process requirements for the future. Initially, approximately 30 additional stamping presses would be required; but simultaneously, seven 4,000 pound annealing furnaces would become unneeded.

The annealing process is costly in time and energy consumption, and those costs would be avoided with the aluminum cent. Over the longer horizon, removal of the annealing furnaces would free space needed for the additional blanking and stamping presses. However, the transition

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[1/] Consult Table 4, page C-14, Appendix C, in A Comprehensive Review of U.S. Coinage System Requirements to the Year 1990, Phase I: Current Denominations and Alloys for the actual manufacturing coefficients. These coefficients are in number of machine-shifts per 1000 coins. RTI assumed 720 machine-shifts per year for the calculations in this chapter.

Table 6-13

Equipment Requirements for Denominations Other Than Cents

Year	Blanking Press	Annealing Furnace[1/]	Stamping Press
1978	3.6	2.2	27.0
1979	3.7	2.3	28.1
1980	3.9	2.4	29.2
1985	4.6	2.8	34.5
1990	5.3	3.2	39.9
TOTAL AVAILABLE	21	10.7	136

[1/] In 4000 pound equivalent furnaces.

Table 6-14

Equipment Capacity Available for One Cent and/or Two Cent Production

Year	Blanking Press	Annealing Furnace	Stamping Press
1978	17	8	109
1979	17	8	108
1980	17	8	107
1985	16	7	101
1990	15	7	96

SOURCE: Tables 6-1, 6-2, and 6-3 in this chapter, and Table 4, page C-14 in A Comprehensive Review of U.S. Coinage Requirements to 1990, Phase I assuming 720 machine shifts per year.

Table 6-15

Manufacturing Process Requirements Under Alternative Strategies of One and/or Two Cent Coin Production 1/

Year	Blanking Press Requirements 2/			Annealing Furnace Requirements 3/4/			Stamping Press Requirements 5/		
Year	Present System	Aluminum Cent	Two Cent Coin	Present System	Aluminum Cent	Two Cent Coin	Present System	Aluminum Cent	Two Cent Coin
1978	9	13	8	6	0	2	92	136	91
1979	10	13	8	7	0	2	102	136	98
1980	11	13	8	7	0	2	112	139	92
1981	13	18	8	8	0	2	124	189	100
1982	14	17	9	9	0	2	136	172	106
1983	15	19	9	10	0	2	150	194	112
1984	17	17	11	11	0	2	164	172	121
1985	18	18	11	12	0	2	180	189	129
1986	20	20	11	13	0	2	195	205	137
1987	22	22	12	14	0	2	213	224	146
1988	24	24	12	15	0	2	231	243	154
1989	25	25	14	16	0	3	250	262	166
1990	28	28	15	17	0	3	271	285	179

1/ There are no requirements if cent is eliminated.

2/ 1.361 billion coins/machine/year.

3/ Aluminum coins do not require annealing.

4/ 2.1544 billion copper-zinc cents/furnace/year.

5/ .1387 billion copper cent coins/press/year; .1321 billion aluminum cent coins/press/year; .1043 billion two cent coins/press/year.

SOURCE: Tables 6-4, 6-5, and 6-6

would be difficult because the additional presses would have to be operational during the period of the furnace removal. Thus, either a satellite facility, such as the West Point and San Francisco facilities, must be utilized during the interim period or a new facility constructed immediately.

By 1981, a new Mint facility must be operational, housing at least two blanking presses (10 percent addition to existing capacity) and 55 stamping presses (40 percent addition to existing capacity). The capacity of the proposed addition would be exceeded by 1986, and another facility would be necessary, containing 96 additional stamping presses and 10 additional blanking presses plus supporting equipment.

In summary, replacing the copper cent with an aluminum coin will reduce the material and direct manufacturing cost per coin. Otherwise, the manufacturing process requirements for the aluminum cent will significantly alter the balance of resource requirements, eliminating the need for most of the annealing capacity and increasing the stamping requirements. The initial production requirements will be accelerated to compensate for the rapid withdrawal of copper cents and future requirements may exceed those of the present coin set if the aluminum cent is perceived as worthless and treated as a nuisance coin.

3.3.2 Manufacturing Requirements With the Introduction of a Two Cent Coin

Restricted production of the cent and introduction of the two cent coin will postpone required expansions of mint capacity beyond those scheduled for the present coin system. Also less expansion is necessary. Introduction of an aluminum two cent coin will increase stamping requiremnts by 1990 to a level 32 percent greater than present capacity; but those requirements will be partially offset by the elimination of annealing requirements for an aluminum two cent coin.

Additional production capacity may be gained by constructing a new facility, displacing inefficient equipment and adding new equipment at existing facilities, and/or contracting manufacturing process functions to private vendors. For the initial capacity expansion necessary after a two cent coin is introduced the latter two options are preferred.

Postponement of extensive capital expansion leaves the Mint with greater flexibility to implement further denomination or compositional changes. In particular, after the two cent coin has circulated for several years the Mint should further assess whether the cent and/or the two cent coins should be eliminated. Extensive initial capital expansion forces a greater commitment to long-term manufacturing of both denominations.

To maintain manufacturing flexibility the Mint should add 28 additional stamping presses in existing mint facilities between 1980 and 1985 which will provide sufficient capacity to satisfy coin requirements (assuming a forced substitution of two cent for one cent coins) to the year 1985.

3.3.3 Manufacturing Implications of Eliminating the Cent

Discontinuing cent production would reduce the manufacturing requirements of the Bureau of the Mint by more than 60 percent. The number of coins manufactured could decline from 13 billion in 1977 to 10.3 billion in 1978 to 4.5 billion in 1979. Total capacity requirement would not exceed 6.3 billion coins annually through 1990.

The total annual requirements for coins, excluding the cent, can be manufactured at either the Philadelphia or the Denver Mint. Rather than sustaining operations at all existing facilities at a suboptimal level, the Mint should consolidate all coin production to a single facility. The Philadelphia Mint is the preferable site due to the age and congestion of the Denver Mint and the limited capabilities at the West Point Bullion Depository.

Table 6-16 contains data for the present capacity of the Philadelphia Mint. There are three types of stamping presses, each with different capacities. Table 6-17 presents the equipment requirements to produce the remaining coin denominations if the cent is eliminated. These requirements are based on the intermediate (or most likely) projections of all denominations with a doubling of nickel and dime demand. The Philadelphia Mint can provide the capacity necessary to manufacture all coins through

Table 6-16

Present Capacity at the Philadelphia Mint

	Blanking Press	Annealing Furnace	Stamping Press		
			Bliss	Columbia	Standard
Total Available	13	5.75	55.0	12.0	3.0

Table 6-17

Equipment Requirements to Produce All Coins to 1995 With the Elimination of the Cent

Year	Blanking Press	Annealing Furnace	Stamping Press		
			Bliss	Columbia	Standard
1980	6	3.4	45.0	-	-
1985	6	4.2	53.4	-	-
1990	8	4.7	55.0	2.2	-
1995	9	5.3	60.3	12.0	3.0

1990. By 1995, only stamping capacity is exceeded when the Mint should purchase five additional stamping presses with capabilities similar to the currently used Bliss type.

3.3.4 Summary and Comparison of Manufacturing Requirements for the One Cent Alternatives

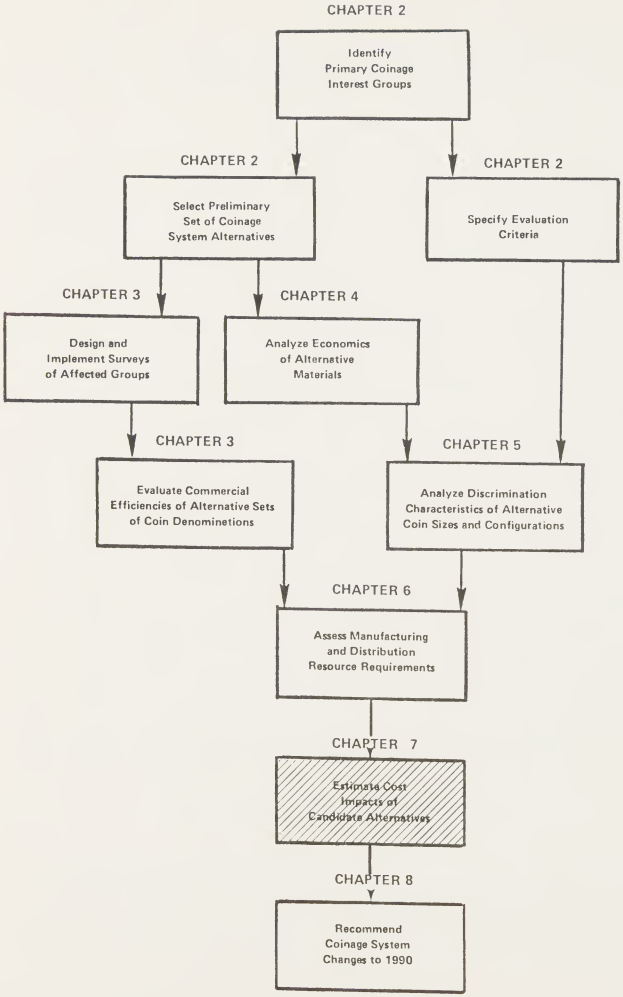
Each of the candidate alternatives to the copper cent will affect manufacturing resource requirements differently. Minting aluminum one cent coinage requirements will eliminate the need for seven 4,000 pound annealing furnaces, while creating an immediate demand for thirty additional stamping presses. The space occupied by the seven unneeded furnaces might eventually be used for stamping presses. However, dismantling and removing the furnaces would be an unwieldy and time consuming undertaking; and a new facility would be required by 1981 to house additional blanking and stamping presses that might be constructed earlier, to allow more efficient production. On the other hand, postponement of the construction might be a less costly option. By 1990, the requirements for aluminum cents will create a demand for thirteen blanking presses and 189 stamping presses more than will be available at that time. The implementation of this alternative will precipitate excess demand for production resources. Satisfying that demand in the most feasible manner will depend to a great extent upon the timing of facility construction and capacity addition.

With the introduction of an aluminum two cent coin, four 4,000 pound annealing furnaces will be excess. The blanking press capacity available in 1990 will be sufficient to manufacture the one and two cent coins, but there will be an excess demand for 83 additional stamping presses at that time. The number of stamping presses required would exceed the number available in 1980. The manner in which the Mint chose to add capacity for this option as well would determine the total costs for capacity and facility expansions.

With the elimination of the cent, all coin requirements could be produced at either the Denver or the Philadelphia Mint. The capacity of either Mint is sufficient to produce the projected coin requirements to 1995 when five additional stamping presses would be required.

4.0 MANUFACTURING RESOURCE REQUIREMENTS WITH THE ONE DOLLAR COIN

The introduction of a more-conveniently-sized one dollar coin will have a very slight impact on manufacturing resource requirements relative to that impact of the cent alternatives. As indicated in Table 6-11, the total coin requirements with the addition of a conveniently sized one dollar coin will total only 2.3 billion during the entire thirteen year period, or an average of 130 million annually after the initial startup production. If the production requirements for the new coin are halfway between those of the current quarter and half dollar, the additional manufacturing requirements will be a maximum of three blanking presses, 0.21 annealing furnaces and two stamping presses during the period of production to 1990. If the introduction of this coin were coupled with the elimination of the cent, the capacity at the Philadelphia Mint would still be sufficient to produce all coin requirements to 1995 when eight (rather than five) additional stamping presses would be required.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design and Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 7

Impacts and Costs Associated With Implementing the Candidate Alternatives to the Present Coinage Set

1.0 INTRODUCTION

Modifications in the denomination, configuration, or material composition of U.S. coins will precipitate adjustments throughout the entire coin manufacturing and distribution network. This network has several parts. The Bureau of the Mint manufactures, stores, and distributes coins to the Federal Reserve banks and branches. They in turn store coins and fill orders for them placed by commercial banks. The commercial banks supply the needs of retail businesses and consumers, providing coins for exchange in commercial transactions. Retail firms also maintain inventories of coins to insure their ability to make change.

Through this report, the various impacts (both positive and negative) that might arise from coinage changes have been described and analyzed. These impacts range from the rounding losses incurred by consumers in transactions if the cent is eliminated, to the annual gains on seigniorage accruing to the Mint with an aluminum cent coin. In this chapter, the costs of these potential effects are examined in more detail.

The introduction of each candidate cent alternative will exert different combinations of impacts on the coinage manufacturing and distribution network. Both the positive and negative impacts of continuing the present coinage set, changing the composition of the cent to aluminum, introducing a two cent coin, and eliminating the cent denomination, are discussed. This chapter also treats the potential impacts associated with a change in the size of the one dollar coin.

2.0 ONE CENT COINAGE ALTERNATIVES

2.1 Maintaining the Copper Cent

Assuming no changes in the present U.S. coinage set, the Bureau of the Mint is rapidly approaching a dilemma brought about by the growing

demand for cents and the increasing costs to the Mint (and ultimately to the public) of manufacturing and distributing cents for use in commercial transactions.

RTI forecasts show a range of 22 to 54 billion coins for the annual cent requirements by 1990, with a most likely estimate of 38 billion cents. Simultaneous with the accelerating cent requirements, the costs to the Mint associated with cent production and distribution are also expected to increase. Table 7-1 and Exhibit 7-1 illustrate the projected cent manufacturing costs to 1990. Between 1980 and 1985, the Mint will enter an era when copper cent production produces negative seigniorage. By 1990, the value of the metal contained in a cent will regularly exceed the face value of the coin.

Table 7-2 presents projections of the face value of cent production (based on the most likely projections of cent demand), the estimated manufacturing costs (based on the data provided in Table 7-1), and the resulting annual seigniorage (equal to the face value of the coins minus their metal plus production costs).[1/] As metal, fabrication, manufacturing, and distribution costs increase, the seigniorage will decline. By 1981 positive seigniorage will end and minting costs will exceed the face value of cent coins. In 1985 a $67 million deficit is projected for the estimated production of 25 billion cents, and a $177 million deficit projected for the 38 billion cent production estimated for 1990.

The cost of cents to the public will be more substantial than manufacturing costs alone. The additional costs associated with the processing of cents incurred by Federal Reserve banks and branches, commercial banks, and retail firms prior to the utilization of these cents in commercial transactions significantly increases the public cost. Table 7-3 contains estimates of these processing costs.[2/]

The cost to Federal Reserve and commercial banks is estimated at $0.03 per 100 coins processed; the cost to retail firms is slightly higher at $0.05 per 100 coins processed. These costs represent the

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[1/] Please refer to Chapter 6 for more detailed information on the projected coin requirements.

[2/] These costs are RTI's best estimates of cent processing costs based on data provided by individual Federal Reserve banks, commercial banks, and retail firms elicited through telephone interviews.

Table 7-1

Actual and Estimated Mint Costs to Manufacture Copper Cent Coins
(in dollars per 100 coins)

Cost Category	Year 1975	1980	1985	1990
Metal[1/]	.464	.723	.967	1.090
Strip Fabrication[2/]	.130	.158	.192	.234
Coinage and Shipping[2/]	.076	.092	.112	.317
TOTAL	.670	.973	1.271	1.461

[1/] Estimated trend in copper prices: 1975 = $.64 per lb. (valued at average purchase price of Mint inventory),
1980 = $1.00 per lb.,
1985 = $1.25 per lb.,
1990 = $1.50 per lb.

Copper is subject to wide variability in short-term prices.

[2/] Strip fabrication, coining, and shipping costs estimated based on four percent annual increases in 1975 actual costs.

Exhibit 7-1

PROJECTED MINT COSTS TO MANUFACTURE CENT COINS

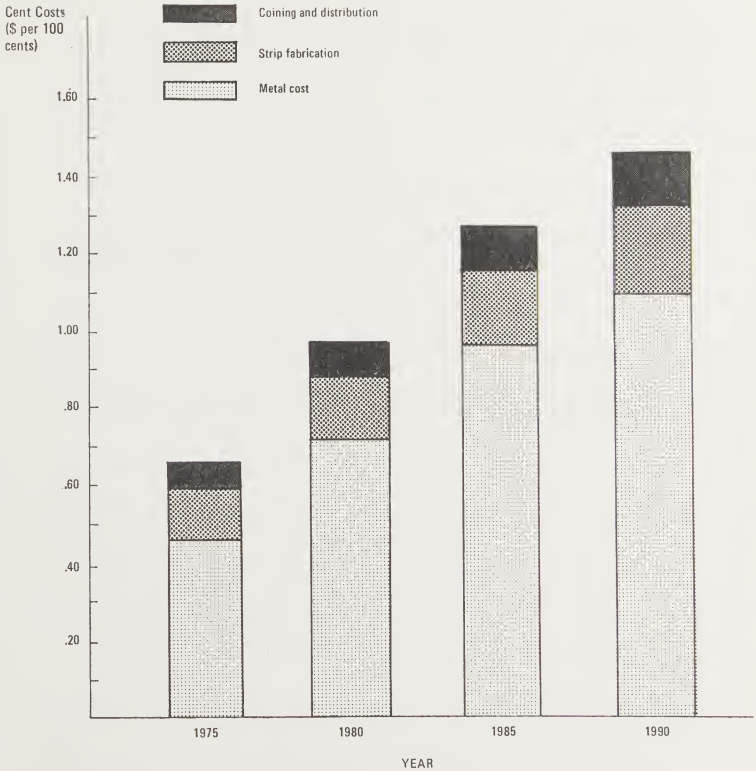


Table 7-2

Projections of Production, Manufacturing Costs and Annual Seigniorage for the Copper Cent 1/
(million dollars)

Year	Face Value of One Cent Production	Production and Distribution Costs	Annual Seigniorage
1975	94	63	31
1978	127	109	18
1979	141	128	13
1980	156	152	4
1981	172	172	0
1982	189	200	-11
1983	208	233	-25
1984	228	267	-39
1985	249	316	-67
1986	271	352	-81
1987	295	389	-94
1988	321	443	-122
1989	347	493	-146
1990	376	549	-173
TOTAL	3,080	3,807	-723
AVERAGE	237	293	-56

1/ Based on data from Tables 6-4 and 7-1.

Table 7-3

Projected Costs of Processing the Present Cent Coin Denomination
(millions of dollars)

Year	Federal Reserve System 1/	Commercial Banks 2/	Retail Firms 3/	Total--Including Manufacturing
1975	3.1	5.7	9.5	81.2
1978	4.6	8.4	10.0	135.8
1979	5.4	9.8	16.3	159.5
1980	6.3	11.4	19.0	188.9
1981	7.2	13.2	22.0	214.2
1982	8.4	15.2	25.3	249.2
1983	10.0	17.6	29.3	289.5
1984	11.1	20.2	33.7	332.1
1985	12.8	23.2	38.7	390.0
1986	14.6	26.5	43.7	437.3
1987	16.6	30.3	50.5	487.2
1988	19.0	34.6	57.7	554.0
1989	21.6	39.3	65.5	619.9
1990	24.6	44.7	74.5	692.8

1/ 1.1 x Annual Net Payout x [$0.03 per 100 coins (increasing 5% annually)].

2/ 2 x Annual Net Payout x [$0.03 per 100 coins (increasing 5% annually)].

3/ 2 x Annual Net Payout x [$0.05 per 100 coins (increasing 5% annually)].

operating (rather than capital) costs incurred by banks and retail firms for recieving, sorting, counting, wrapping, storing in vaults and distributing cent coins.

Obviously the number of cent coins handled by the Federal Reserve banks, commercial banks, and retail firms depends upon the use of the cent coin in their very different operations. Consequently, the base number coins used in estimating the costs to each sector was different. Federal Reserve banks receive the cent coins produced by the Mint to distribute them to the commercial banks. They also receive an estimated one-tenth of the payout back from the commercial banks, resulting in their processing 1.1 times the net annual payout of cents from the Mint. Commercial banks were estimated to process the annual net payout of cents twice. Retail business firms were estimated to incur higher unit processing costs than banks for handling and distributing cents as change in commercial transactions.

The total public cost of maintaining a circulating pool of cents therefore includes not only the manufacturing and distribution costs incurred by the Mint, but also the processing and handling and inventory costs incurred by Federal Reserve banks, commercial banks, and retail firms. Exhibit 7-2 illustrates these total costs for each cent manufactured; they increase from $0.86 per 100 cents manufactured in 1975 to a projected $1.84 per 100 cents manufactured in 1990.[1/] During this fifteen year period, the percentage of net payout that simply constitutes replacements for attrition will increase. By 1990, less than 20 percent of net payout will add to the circulating pool. Exhibit 7-3 illustrates the total cost for cents that are additions to this pool. (See Appendix F for cost computations.) These costs increase from $2.69 per 100 cents in 1975 to $10.25 per 100 cents in 1990.[2/] Therefore the total cost to the public of adding one cent coins to the circulating pool will exceed their face value by nine cents.

[1/] These costs include Mint manufacturing costs and circulation costs to Federal Reserve banks, commercial banks, and retail firms. These total costs are divided by net payout to calculate a unit cost.

[2/] These costs differ from the first costs in that they are the unit costs for each cent added to circulation. To derive them, the total manufacturing and circulation cost was divided by only that percentage of net payout constituting a net addition to the circulating pool.

EXHIBIT 7-2

PROJECTED TOTAL COST PER ONE CENT COIN MANUFACTURED

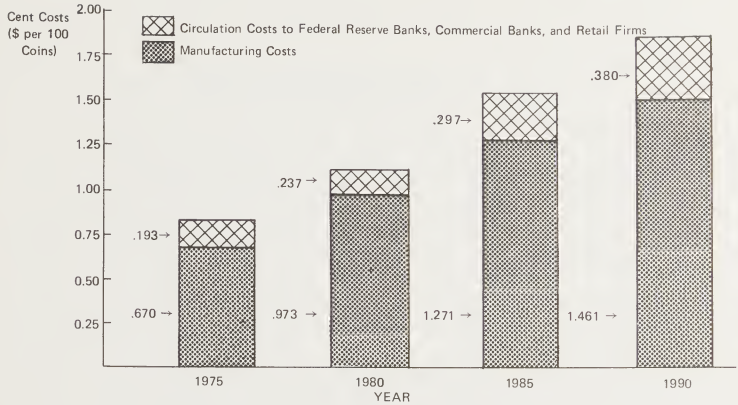
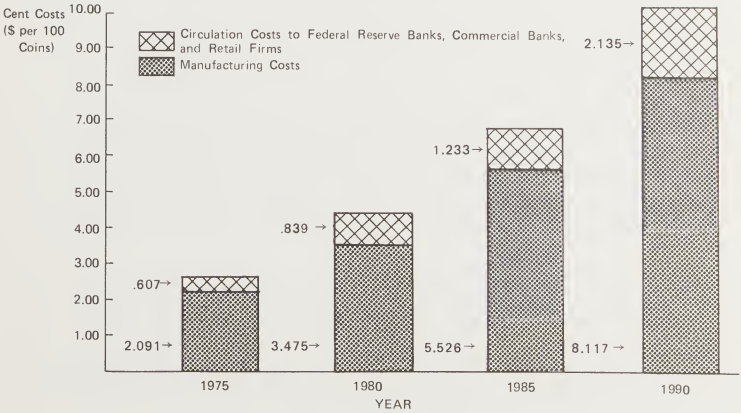


EXHIBIT 7-3

PROJECTED TOTAL COST PER ONE CENT COIN ADDED TO CIRCULATION



2.2 Changing the Composition of the Cent to Aluminum

Satisfying the demand for aluminum cents as projected in Chapter 6 will require increased Mint capacity and corresponding capital investments. This change would create an immediate need for 27 additional stamping presses at an estimated total purchase and installation cost of $3 million. By 1981, a new Mint facility must be operational housing at least two blanking presses, 55 stamping presses and requiring a capital investment of $90 million. The capacity of this proposed addition would be exceeded by 1986 when another facility containing 96 additional stamping presses, 10 additional blanking presses and supporting equipment would be necessary. The estimated cost of that facility, built to provide the additional capacity required to 1990, is $85 million.

An aluminum cent will have one third the weight and cost to the Mint of the present copper cent. The manufacturing process requirements differ substantially between the copper and aluminum cents. No annealing is required for aluminum coin blanks, and while the blanking press requirements are equivalent for copper and aluminum cents, approximately five percent greater stamping press capacity is required for aluminum due to the estimated reduction in die life. The estimated costs for minting aluminum cents are presented in Table 7-4. These manufacturing cost data provide the basis for projecting the annual seigniorage for aluminum cents.

Table 7-5 contains the projections of the face value of the aluminum cents produced, their manufacturing costs, and the difference between the two, equivalent to the annual seigniorage. This annual seigniorage would average $133 million for the first three years of production and $189 million annually for the following decade. By 1990 the annual seigniorage would be $233 million.

The primary advantages to the Department of the Treasury of changing the composition of the cent to aluminum are the cost savings and protection from copper hoarding problems. However, much of the increased demand for cents will be to replace the increasing attrition of cents from circulation as their value in commerce continues to decline. If the public does perceive the aluminum cent as having even less intrinsic value than the copper cent, the annual increase in the attrition rate

Table 7-4

Estimated Mint Costs to Manufacture the Aluminum Cent
(Dollars per 100 Coins)

Cost Category	Year 1975	1980	1985	1990
Metal[1/]	.096	.123	.156	.200
Strip Fabrication[2/]	.060	.073	.089	.107
Coining	.070[3/]	.089	.114	.146
Shipping	.004[4/]	.005	.007	.008
TOTAL	.230	.290	.366	.461

[1/] Assumes: 481 coins per pound of ingot; 27 percent scrap rate (at $.24 per lb.) in conversion to strip; 1975 ingot price, $.36 per lb., assumed to increase by 5% annually.

[2/] 354 coins per pound of strip; 27 percent scrap rate in blanking. Purchased strip costs (including ingot) = $.57 per pound.

[3/] Based on FY 1975 costs for cents at Philadelphia for purchased strip. Excludes 75% of annealing cost.

[4/] Based on [average shipping cost for cents from Philadelphia] ÷ [ratio of aluminum cents per pound to copper cents per pound] x [adjustment for handling] = [.012 ÷ 3.26] x 1.2 = .004.

Table 7-5

Projections of Production, Manufacturing Costs, and Annual Seigniorage for Aluminum Cents 1/
(million dollars)

Year	Face Value of One Cent Production	Production and Distribution Costs	Annual Seigniorage
1978	181	49	132
1979	180	50	130
1980	183	53	130
1982	250	76	174
1982	228	73	155
1983	257	87	170
1984	228	82	146
1985	249	92	157
1986	271	106	165
1987	295	118	177
1988	321	135	186
1989	347	153	194
1990	370	170	200
TOTAL	3,360	1,244	2,116
AVERAGE	258	96	163

1/ Based on data in Tables 6-5 and 7-4.

SOURCE: Research Triangle Institute.

will be greater than projected, resulting in higher production requirements, greater capacity needs and consequently more expensive capital investments. With an attrition rate equal to the copper cent, aluminum cent production will require that present Mint capacity more than double to manufacture the requirements in 1990. By then, over 90 percent of the production will be allocated to production of aluminum cents. If the value of the cent to the public should decline to a state of essential worthlessness, subsequent elimination of the cent would dramatically affect the Mint resources.

The accelerated expansion in Mint capacity would then be followed by a cutback which in 1990 could entail a reduction in force of over 1,500 employees and a capital writeoff of over $180 million.

The introduction of an aluminum cent coin will also affect the Federal Reserve system, commercial banks, retail firms and automatic merchandising firms, primarily as a function of the difference in weight between copper and aluminum cents. Several larger banks including Federal Reserve banks or branches, which handle large numbers of cent coins, now weigh them for verification and counting. During a transition period, as copper cents cocirculate with aluminum cents, this method of processing cent coins will be obsoleted. Counting cent coins will necessarily be performed by alternative, and consequently more expensive method. Initially, manual sorting of copper and aluminum cents will be required.

Table 7-6 contains the estimates of processing costs for the Federal Reserve system, commercial banks, and retail firms projected to 1990 based on the production requirements for aluminum cents as discussed in Chapter 6. Included in these estimates is a somewhat higher cent processing cost for the Federal Reserve banks, and commercial banks, accounting for the diseconomies of initiating an alternative cent handling procedure. As illustrated in this table, the total cost for processing aluminum cents is projected at $85.5 million in 1978 increasing to $322.3 million by 1990. The total costs for processing aluminum cents over this thirteen year period are 11 percent greater than the comparable costs for processing copper cents. However, these higher processing costs only marginally offset the net gains in seigniorage.

Table 7-6

Projected Costs of Processing the Minor Coin Denominations with Aluminum Cents
(million dollars)

Year	Federal Reserve System 1/	Commercial Banks 2/	Retail Firms 3/	Total
1978	8.8	16.0	20.0	44.8
1979	9.2	16.7	20.9	46.8
1980	9.8	17.8	22.3	49.9
1981	14.0	25.5	31.9	71.4
1982	13.4	24.4	30.5	68.3
1983	15.9	28.9	36.1	80.9
1984	14.8	27.0	33.8	75.6
1985	17.0	30.9	38.6	86.5
1986	19.4	35.3	44.1	98.8
1987	22.2	40.4	50.5	113.1
1988	25.4	46.1	57.6	129.1
1989	28.8	52.4	65.5	146.7
1990	32.8	59.6	74.5	166.9

1/ 1.1 x Annual Net Payout x [$0.04 per 100 coins (increasing 5% annually)].

2/ 2 x Annual Net Payout x [$0.04 per 100 coins (increasing 5% annually)].

3/ 2 x Annual Net Payout x [$0.05 per 100 coins (increasing 5% annually)].

SOURCE: Research Triangle Institute.

Another group of coin users, the automated merchandisers, would be affected by a change in the composition of the cent to aluminum. Many of the vending machines used for automatic merchandising now automatically reject copper cents. This rejection is accomplished by the weight of the cent pushing aside a cradle in the coin acceptance mechanism. The lighter weight aluminum cent coin could not activate this automatic rejection: the consumer would have to release the coin manually by depressing the coin return button or lever. If other coins were deposited into the machine while an aluminum cent rested in the cradle, they could build up, possibly resulting in a jamming of the mechanism. Costs associated with vending machines jams are estimated to be $17.0 million annually during the first two years after the introduction of the aluminum cent.

2.3 The Introduction of a Two Cent Coin

The two cent denomination was selected as the most acceptable additional minor coin on the basis of its potential efficiency in exchange. However, opinion research indicated that a two cent coin would not be readily accepted as a substitute for the cent coin, so this alternative is premised upon a forced substitution through restricted production of one cent coins.

Restricted production of the cent and introduction of the two cent coin may defer expansions of mint capacity beyond those scheduled for the present coin system. Only the stamping press capacity is exceeded by 1990 when 96 additional presses would be required, representing a 68 percent increase over the present stamping capacity. However, those requirements would be partially offset by the elimination of annealing requirements if the two cent coin were aluminum.

Additional production capacity may be gained by constructing a new facility, replacing inefficient equipment with new equipment at existing facilities, and/or contracting manufacturing process functions to private vendors. For the initial capacity expansion necessary after a two cent coin is introduced the latter two options are more consistent with present policy.

Postponement of extensive capital expansion leaves the Mint with greater flexibility to implement further denomination or composition changes. In particular, after the two cent coin has circulated for several years the Mint should then assess whether the cent and/or the two cent coins should be eliminated. Extensive initial capital expansion forces a greater commitment to long term manufacturing of both denominations.

To maintain manufacturing flexibility the Mint could add 28 additional stamping presses in existing mint facilities by 1985 at a cost of $4 million. This addition will provide sufficient capacity to satisfy coin requirements (assuming a forced substitution of two cent for one cent coins) through 1985.

Table 7-7 compares the estimated manufacturing costs for aluminum and brass two cent coins. The costs for minting and distributing the brass coin are three times higher than those of the aluminum coin, for the most part due to the higher metal cost. Based on these data and the projections of coin requirements from Chapter 6, the annual seigniorage from the manufacture of one cent and two cent coins was computed. The face value of the coins, their production costs and the resulting seigniorage are included in Table 7-8 for the aluminum two cent coin and Table 7-9 for the brass two cent coin. The aluminum cent coin provides much greater seigniorage than the brass two cent coin. If production of the copper cent is continued after 1981, when negative seigniorage would begin, the total seigniorage for both the one cent and brass two cent coins maintains through 1990, but decreases rapidly. Conversely, the positive seigniorage for the aluminum two cent coin far outweighs the negative seigniorage of the cocirculating copper cent. Based on this differential in seigniorage (manufacturing costs) it is recommended that a two cent coin if introduced be minted of aluminum.

Table 7-7

Estimated Costs to Manufacture Two Cent Coins[1/]
(Dollars per 100 Coins)

	Cost Category	Year 1975	1980	1985	1990
Aluminum Two Cent Coin	Metal[2/]	.107	.137	.175	.223
	Strip Fabrication[3/]	.067	.081	.099	.119
	Coining[4/]	.070	.089	.114	.146
	Shipping	.005	.006	.008	.009
	TOTAL	.249	.313	.396	.497
Brass Two Cent Coin	Metal	.498	.757	1.004	1.124
	Strip Fabrication	.146	.177	.216	.263
	Coinage and Shipping	.086	.103	.126	.154
	TOTAL	.730	1.037	1.346	1.542

[1/] Assume: diameter = 20.13 mm, thickness = 1.57 mm.

[2/] 431 coins per lb. of ingot; 1975 ingot price of $.36 per lb., increasing by 5% annually. Metal cost includes allowance for 27% scrap rate in conversion to strip, with scrap valued at $.24 per lb.

[3/] Estimated from aluminum cent costs according to ratio of surface areas; 101.3 to 90.7.

[4/] Equivalent to aluminum cent costs.

Table 7-8

Projections of Production, Manufacturing Costs, and Annual Seigniorage for Copper Cent and Aluminum Two Cent Coins 1/
(Million Dollars)

Year	Face Value of Production		Production and Distribution Costs		Annual Seigniorage
	One Cent	Two Cent	One Cent	Two Cent	
1978	40	130	34	19	117
1979	40	144	36	22	216
1980	40	132	39	21	112
1981	40	148	40	24	119
1982	40	160	42	28	130
1983	40	174	45	32	137
1984	40	192	47	36	149
1985	40	208	51	41	156
1986	40	224	52	47	165
1987	40	242	53	53	176
1988	40	260	55	59	186
1989	64	250	91	59	164
1990	75	260	110	65	160
TOTAL	579	2,530	695	506	1,987
AVERAGE	45	194	53	39	153

1/ Based on data from Tables 6-8 and 7-7.

SOURCE: Research Triangle Institute

Table 7-9

Projections of Production, Manufacturing Costs, and Annual Seigniorage for Copper Cent and Brass Two Cent Coins 1/
(Million Dollars)

Year	Face Value of Production		Production and Distribution Costs		Annual Seigniorage
	One Cent	Two Cent	One Cent	Two Cent	
1978	40	130	34	59	77
1979	40	144	36	70	78
1980	40	132	39	68	65
1981	40	148	40	81	67
1982	40	160	42	93	65
1983	40	174	45	106	63
1984	40	192	47	123	62
1985	40	208	51	140	57
1986	40	224	52	155	57
1987	40	242	53	172	57
1988	40	266	55	195	56
1989	64	250	91	188	35
1990	75	260	110	200	25
TOTAL	579	2,530	695	1,650	764
AVERAGE	45	194	53	127	59

1/ Based on data from Tables 6-8 and 7-7.

SOURCE: Research Triangle Institute.

Beyond 1985, three alternatives could be considered for the Mint expansion strategy: continuation of both the one and two cent denominations, yielding a negative seigniorage of $102 million for one cent coins between 1985 and 1990, and requiring of a new mint at an estimated cost of $90 million; continuation of the two cent and deletion of the one cent beyond 1985, in which case the production capacity in 1985 will be sufficient to 1990; and discontinuing both the one and two cent coins.

Obviously, introduction of the two cent coin allows a mix of strategies by the Mint. The first strategy will maintain a longer-term stability in the Mint of coin denominations at the expense of capital expansion and negative seigniorage; the second will lessen the impact from cent elimination; and the third strategy will allow a smoother delayed transition to elimination of the cent.

Although the other two strategies are less costly to the Government, the first strategy of continued production of both the one and two cent coins is compared against the impacts of the other candidate alternatives. The addition of a two cent coin to the currently-minted denominations will reduce the requirements of one cent coins and costs associated with their handling. However, the introduction of this additional denomination will require modification or replacement of coin sorting and other coin processing equipment currently used by retail firms and banks. In addition, modifications of the coin acceptor/rejector mechanisms in most of the standard vending machines will be necessary to insure that the coin is accepted as valid, or automatically rejected. Furthermore, the increased complexities of handling and accounting for an additional minor coin denomination may cause public resistance to its use.

Costs would be incurred by Federal Reserve Banks, commercial banks, and retail firms to maintain an adequate supply of both one and two cent coins. These costs would be incurred for shipping, sorting, counting, wrapping, and storing of the coins. Costs for both denominations, projected to 1990, are presented in Table 7-10. They reflect the greater expense associated with handling a larger coin, as well as the complexity of handling an additional denomination. The resulting total

Table 7-10

Projected Costs of Processing the Minor Coin Denominations With the Addition of a Two Cent Coin
(Million Dollars)

Year	Federal Reserve System 1/	Commercial Banks 2/	Retail Firms 3/	Total
1978	5.0	12.1	15.1	32.2
1979	5.7	13.7	17.1	36.5
1980	5.6	13.5	16.9	36.0
1981	6.4	15.4	19.3	41.1
1982	7.1	17.2	21.5	45.8
1983	7.9	19.2	24.0	51.1
1984	9.0	21.8	27.3	58.1
1985	10.0	24.3	30.4	64.7
1986	11.2	27.1	33.9	72.2
1987	12.5	30.3	37.9	80.7
1988	13.9	33.8	42.3	90.0
1989	15.6	37.9	47.4	100.9
1990	17.6	42.8	53.5	113.9

1/ For one cent coins: 1.1 x Annual Net Payout x [$0.03 per 100 coins (increasing 5% annually)]
For two cent coins: 1.1 x Annual Net Payout x [$0.045 per 100 coins (increasing 5% annually)]

2/ For one cent coins: 2 x Annual Net Payout x [$0.04 per 100 coins (increasing 5% annually)]
For two cent coins: 2 x Annual Net Payout x [$0.06 per 100 coins (increasing 5% annually)]

3/ For one cent coins: 2 x Annual Net Payout x [$0.05 per 100 coins (increasing 5% annually)]
For two cent coins: 2 x Annual Net Payout x [$0.075 per 100 coins (increasing 5% annually)]

costs are only slightly less than the costs projected for keeping the current cent in circulation. Although there will be fewer coins, the higher cost of circulating the two cent coins will translate into only marginal coin processing savings over the present system.

With the addition of a new coin denomination, modification or replacement of coin processing equipment will be a major cost element. Any business utilizing automatic coin processing equipment will have a limited number of options: to process the new coin manually, to modify existing equipment to handle the coin, or to purchase new equipment designed to process the coin.

Various questions were asked through the survey of the selected groups of coin users to ascertain the numbers and types of coin processing equipment utilized, and the estimated costs of modifying or replacing that equipment in the event of the introduction of a two cent coin. To correlate these sample data with the universe of potentially-affected coin users, various measures of size were also recorded for each surveyed group. For retail merchandising firms, their total dollar sales in 1974 was recorded, while total deposits were recorded for commercial banks.

The total sales of all responding firms for which sales data were available was $83,402 million or an average of $485 million per firm. To compare the size of the group of responding firms with the universe of potential respondents in this category, a comparable figure for the U.S. for 1973 was calculated to be $298,610 million.[1/] The firms responding to the questionnaire therefore represented an estimated 27.9 percent of all sales in these categories (retail, food, fast food and drugs) in 1973.

The total deposits in 1974 for each commercial bank provided a measure of bank size and transactions activity. The total deposits for all the banks responding to the survey and included in this analysis were $443,151 million for 1974, representing 61.9 percent of the total deposits for all commercial banks in the U.S. in 1974.[2/]

[1/] The sales figure for the U.S. was calculated as the retail sales of all nondurable goods stores minus sales from gasoline service stations, Survey of Current Business, November, 1974, Volume 54, Number 11.

[2/] FCIC Summary of Deposits in All Commercial and Mutual Savings Banks, June 29, 1974. (This figure includes both insured and noninsured banks.)

Retail firms were also requested to supply information regarding the number and type of coin processing equipment utilized in their business operations. The cash register is the type of machine most often used in commercial transactions. Coin payers or cashiers may also be used for automatically paying out change. Each bank also reported the number and types of coin processing equipment used in its organization. The most commonly used type of equipment as reported by the responding banks is the coin payer or automatic cashier.

Assuming that numbers of coin processing equipment were perfectly correlated with sales for retail firms, and deposits for commercial banks, one could infer that 28.0 percent of all coin processing equipment utilized in commercial banking were represented in the survey. This assumption is not without substance. Cross tabulations of the volume of sales for retail firms with the numbers of coin processing equipment owned by each firm indicated a high positive correlation between these two variables. That is, the larger the volume of coins handled (or simply "sales"), the greater the number of machines necessary to process them. This assumption enables the normalizing of the numbers of equipment reported through the survey to industry level figures as presented in Table 7-11 for retail firms, and Table 7-12 for commercial banks.

These tables also include the estimated average modification and replacement costs for the specified types of equipment. Although the modification of a specific brand and model may vary significantly with these estimates, they represent the most likely average costs based on information provided by the manufacturers of this equipment and the surveyed respondents themselves.

The cash registers used by retail firms could be modified simply by replacing the till, resulting in a minimal cost of $20. Conversely, one major manufacturer of automatic coin payers indicated that they could not be modified; their average replacement cost is estimated at $600. Assuming that half of each of the remaining types of equipment would be modified and half replaced, RTI computed cost impacts of $125 million for the retail merchandising industry and $53 million for the commercial banking industry. Similar modification and replacement costs were estimated for Federal Reserve banks and branches at $0.5 million.[1/]

[1/] Based on an estimated 400 coin counting, sorting, and wrapping machines.

Table 7-11

Coin Processing Equipment Used by Retail Firms; Estimated Replacement and Modification Costs

Type of Equipment	Quantities Reported by Respondents: Total	Median[1/]	Mean[1/]	Average Number Per Million $ of Sales	Totals Estimated for All Retail Firms	Estimated Costs Per Unit[2/]: Modification	Replacement
Cash Registers	244,808	275	1,724	2.94	877,400[3/]	$ 20[4/]	--
Coin Payers or Cashiers	13,245	100	414	0.16	47,500	--	$ 600
Coin Sorters	2,141	25	102	0.03	7,700	$ 1,000	$ 2,500
Sorter-Counters	2,612	13	73	0.03	9,400	$ 1,500	$ 5,000
Coin Packagers	1,348	30	84	0.02	4,800	$ 1,500	$ 6,000
Counter-Packagers	1,013	5	78	0.01	3,600	$ 2,000	$10,000

1/ Not all respondents reported use of this equipment. These statistics were based on those who did.

2/ Based on suggestions by manufacturers and survey responses.

3/ All retail firms of the type included in the survey. Total number of cash registers in the U.S. is estimated at 2,000,000.

4/ Modification of cash registers would entail a replacement of the till tray.

SOURCE: Research Triangle Institute.

Table 7-12

Coin Processing Equipment Used in Commercial Banking; Estimated Replacement and Modification Costs

Type of Equipment	Quantites Reported by Respondents: Total	Median Number Per Bank	Mean Number Per Bank	Average Number Per Billion $ of Deposits	Totals Estimated for All Commercial Banks	Estimated Cost Per Unit[2/]: Modification	Replacement
Coin Payers or Cashiers	31,260	125	244	70.5	50,500	--	$ 600
Coin Sorters	617	3	11	1.4	1,000	$ 1,000	$ 2,500
Sorter-Counters	1,682	3	13	3.8	2,700	$ 1,500	$ 5,000
Packagers	540	3	7	1.2	900	$ 1,500	$ 6,000
Counter-Packagers	866	3	9	2.0	1,400	$ 2,000	$10,000

1/ Not all respondents reported use of this equipment. These statistics are based on those who did.

2/ Based on suggestions by manufacturers and survey responses.

SOURCE: Research Triangle Institute.

The burden of modifying the coin processing equipment would most likely fall on the manufacturers of such equipment. Alternative models of coin equipment that would sort or count the two cent coin would be demanded by retail firms and commercial banks as their equipment in place was rendered obsolete. This increased demand may be seen by some members of the industry as a positive impact. However, some brands of equipment may be modified more easily than others, resulting in differential impacts across the industry, and perhaps a subsequent shifting of market concentration. If the manufacturer of a coin sorter used in a commercial bank could not modify the equipment expeditiously or at a reasonable cost, the commercial bank would most likely change to an alternative model that could be more easily modified or a new model manufactured to sort the two cent coin. The potential impacts on this industry are not easily quantifiable and would depend upon the technology available to each individual manufacturer of coin processing equipment. One surveyed manufacturer responded:

> "We build machines and complete systems for delivering coins, for sorting coins, for counting and packaging coins, etc. The machines for paying and delivering coins are used by banks, theaters, resturants, etc. The coin sorter and the coin packaging machines are used by automatic merchandising, by banks, telephone companys, by tollway systems, transportation terminals, etc. Any changes in coin size or the addition of coins would obsolete 200,000 or more machines now in use."

A lightweight aluminum coin which could be mistaken for a nickel could not be automatically rejected by many of the vending machines currently employed in automatic merchandising. The consumer would have to release the coin manually by depressing the coin return button or lever. If other coins were deposited into the machine while an aluminum two cent coin rested in the cradle, a jamming of the coin mechanism might result. Based on the estimated probability of this occurence and estimated costs for alleviating the jams, the automatic merchandising industry could experience annual costs of $25.5 million during the first two years after the introduction of the two cent coin.

2.4 Elimination of the Cent Coin

Discontinuing cent production would reduce the manufacturing requirements of the Bureau of the Mint by more than 60 percent. The number of coins manufactured could decline from 13 billion in 1977 to 10.3 billion in 1978 to 4.5 billion in 1979. Total capacity requirements would not exceed 6.3 billion coins annually through 1990.

The total annual requirements for coins, excluding the cent, can be manufactured at either the Philadelphia or the Denver Mint. Rather than sustaining suboptimal levels of operations at all existing facilities, the Mint should consolidate all coin production at a single facility. The Philadelphia Mint is the preferable site due to the age and congestion of the Denver Mint and the limited capabilities at the West Point Bullion Depository. The capacity at the Philadelphia Mint is ample to produce the projected coin requirements through 1990, and would encounter stamping capacity constraints only by 1995.[1/]

Table 7-13 contains cost estimates for manufacturing nickels and dimes after discontinuing the penny. Table 7-14 presents the estimates of the face value of additional nickels and dimes produced, their manufacturing costs and the annual seigniorage to the Mint. The direct short-term financial impacts on the Bureau of the Mint of a fifty percent reduction of cent production in 1978 and termination thereafter will amount to an estimated gain in seigniorage to 1980 of $357 million, due to the increased requirements for nickels and dimes. However, the associated economic effects are substantial. The immediate impacts include:

a. Removal of Mint operations and a reduction in force of 480 persons in Denver and 54 persons in West Point.

b. A cutback of 4,500 shipments of coins, coin strip, and scrap annually; creating losses in revenue of over $2 million to the trucking industry.

c. A reduction in purchases of 100 million pounds of coin strip by the Mint; producing a loss in direct revenues of $14 million to the strip manufacturers.

[1/] Please refer to Chapter 6, Section 3.3.3.

Table 7-13

Estimated Mint Costs to Manufacture Nickels and Dimes
(In Dollar Per 100 Coins)

	Cost Category	Year			
		1975 1/	1980	1985	1990
NICKELS	Metal 2/	.959	1.498	1.872	2.246
	Manufacturing 3/	.563	.719	.917	1.170
	Shipping 3/	.022	.028	.036	.046
	TOTAL	1.544	2.245	2.825	3.462
DIMES	Metal 2/	.339	.530	.662	.794
	Manufacturing 3/	.339	.433	.552	.705
	Shipping 3/	.015	.019	.024	.031
	TOTAL	.693	.982	1.238	1.530

1/ Based on actual 1975 data.

2/ Metal costs assumed to increase at same rate as projected for copper.

3/ Assumed to increase five percent annually.

Table 7-14

Projections of Production, Manufacturing Costs and Annual Seigniorage With the Elimination of the Cent 1/
(Million Dollars)

Year	Face Value of 1¢ Production	Face Value of Additional Nickel Production	Face Value of Additional Dime Production	Production and Distribution Costs for Cents, Nickels, and Dimes	Annual Seigniorage
1978	60	38	100	75	123
1979	0	38	105	26	117
1980	0	40	105	28	117
1981	0	40	110	30	120
1982	0	42	115	34	123
1983	0	42	120	36	126
1984	0	45	120	39	126
1985	0	45	125	41	129
1986	0	48	130	45	133
1987	0	48	135	48	135
1988	0	50	135	51	134
1989	0	50	140	54	136
1990	0	52	145	59	138
TOTAL	60	578	1,585	566	1,657
AVERAGE	5	45	122	44	127

1/ Includes nickel and dime production and distribution costs and annual seigniorage.

The net societal effects of the above impacts are impossible to measure. Rapid termination of 75 percent of Mint production will displace human and capital resources and eliminate a market for products and services for the private sector. The net effects will depend upon the success of the displaced employees in obtaining alternative employment, on the Government's ability to salvage the excess plant and equipment, and on the private vendors' success at finding alternative markets for their products.

The primary advantage to the Government of implementing this strategy is that immediate resolution of the cent dilemma will be less costly than increasing Mint capacity to meet an artificial demand caused by the cent's minimal purchasing power. Eventually, an alternative action must be taken, and the minimum displacement of personnel and resources will occur if that action is taken soon rather than later.

There will be some additional coin processing costs to Federal Reserve Banks, commercial banks and retail firms to handle additional nickels and dimes in circulation. Table 7-15 contains projections of these estimated processing costs based on unit costs similar to those estimated for handling the two cent coin. Nonetheless, in 1990, these costs would be only one-tenth those estimated for processing the copper cent.

Commercial banks, retail firms, the State Departments of Revenue responsible for administering sales taxes, and consumers will be affected by the elimination of the cent. Various questions were asked through the survey to ascertain the types and magnitudes of the potential impacts.

Most of the commercial banks surveyed (73.3 percent) indicated that no changes in clerical work or coin handling procedures would be implemented if the cent coin were discontinued. Responding banks expecting to incur costs in a transition period after the elimination of the cent comprised only 17.4 percent of those surveyed. The estimated costs ranged from $543 to $1,032,600, with a median cost of $26,000, and a mean cost of $108,300. To the extent that these cost estimates are based on deposits,[1/] an estimated cost of $5 million may be incurred by commercial banks.

[1/] Commercial banks responding to the survey held 61.9 percent of all deposits in the U.S. in 1974.

Table 7-15

Projected Costs of Processing Nickels and Dimes After Elimination of the Cent

Year	Federal Reserve Banks 1/	Commercial Banks 2/	Retail Firms 3/	Total
1978	1.4	2.4	7.6	11.4
1979	1.5	2.6	8.2	12.3
1980	1.6	2.8	8.8	13.2
1981	1.7	3.1	9.6	14.4
1982	1.9	3.4	10.6	15.9
1983	2.0	3.6	11.4	17.0
1984	2.2	3.9	12.2	18.3
1985	2.4	4.2	13.1	19.7
1986	2.6	4.6	14.4	21.6
1987	2.8	5.0	15.5	23.3
1988	3.0	5.3	16.6	24.9
1989	3.2	5.7	17.8	26.7
1990	3.5	6.2	19.5	29.2

1/ 1.5 x Annual Net Payout x [$0.045 per 100 coins (increasing 5% annually)].

2/ 2 x Annual Net Payout x [$0.060 per 100 coins (increasing 5% annually)].

3/ 5 x Annual Net Payout x [$0.075 per 100 coins (increasing 5% annually)].

Costs incurred by retail firms would most likely be greater since the necessary changes in business procedures would be more complex. Merchandise prices would be rounded, the clerical staff retrained in computing sales taxes, and electronic cash registers would have to be reprogrammed. However, 56.5 percent of the surveyed retail firms indicated that no changes in clerical work or coin handling procedures would be implemented. In addition, only 8.1 percent of the firms anticipated costs associated with eliminating the cent. These estimated costs ranged from $100 to $2,089,600, with a median cost of $30,000 and a mean cost of $276,000. If these costs reported in the survey are representative of the expected magnitude of costs, an estimated $15 million might be incurred by all retail firms.[1/] However, in light of the problems with rounding, as described in Chapter 3 and below, these estimates may be grossly underestimated.

The primary use of the cent denomination is as a unit of account; the coin itself is used only in cash transactions. If the cent coin were eliminated, the unit of account could still be used with rounding required only in cash transactions. However, two units of account: $0.05 for cash transactions, and $0.01 for all other transactions may be conceptually difficult to comprehend.

Commercial banks and those retail businesses involved primarily in check or credit card transactions (generally high valued) would experience little difficulty relative to businesses specializing in low valued transactions comprised of a small number of items. A system of transactions and accounting based on two units would be confusing to retail clerks and the general public, perhaps precipitating an increase in the use of checks or credit cards for lower valued purchases.

The retail firms will be faced with a pricing and rounding dilemma. If the price of an item is 12¢ and the tax is 1¢, the total transaction would be valued at 13¢. If prices were rounded down at 12¢ and up at 13¢, 15¢ would be collected from the consumer, who would perceive the "tax" as 3¢. The retailer will have an incentive to price goods at a

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[1/] Retail firms responding to the survey represented 27.9 percent of retail sales in 1973.

level so that the anticipated transaction price plus tax would end in -3 or -8 and be rounded up. This responsibility for rounding would create an additional complication for retail sales clerks. To balance the cash register at the end of the day, the net effects of purchase prices, sales taxes and rounding must be accounted for.

Potentially the greatest costs resulting from the elimination of the cent would be incurred by the consumer in the rounding of retail transactions. If transactions were rounded up and down with equal frequency, no net gain or loss would result. If the merchant gained an average of 0.5¢ per transaction, the loss to the public would be in excess of $1 billion (refer to Table 7-16). This loss represents only 0.51 percent of the total value of cash transactions. However, it comprises a much greater percent of lower valued transactions: 0.5¢ represents an increase ranging from 0.5 percent on a $1 item to two percent on a 25¢ item.

The overall impact on consumers due to rounding cannot be estimated precisely, because it will consist of the net effect of retail pricing strategies and consumer purchasing strategies. Merchants may price products to take advantage of rounding gains only for uniform repetitive transactions; for example, pricing an admissions ticket or pricing hamburgers and soft drinks at fast food stores. When transactions generally involve varied multiple items, such as in discount or grocery stores, pricing gains will be minimal.

The consumer generally selects the combination of goods to be purchased. Thus, if rounding occurred to his disadvantage the consumer could add an additional item to his purchase, such as a 2¢ mint, or discard an item in order to produce rounding in his favor.

Finally, from a marketing perspective the competitive nature of the retail sales industry will continue to be the dominant influence on pricing strategies, and strategies capitalizing on rounding will be effective only in isolated segments of the industry.

On the basis of the factors listed above, the potential loss to consumers due to rounding is estimated at the maximum of $1 billion shown in Table 7-16, but is realistically anticipated to be less.

Table 7-16

Estimated Public Loss Incurred With Rounding

Average Value of Transaction 1/	Number of Cash Transactions of Each Size (Billions) 1/	Total Value of Transactions (Billions)	Average Rounding Loss Per Transaction (Percent) 2/	Rounding Loss (Million $)
$0.25	162	$40.5	2.00	$810.0
$3.50	43	$150.5	0.14	$210.7
$10.00	11	$11.0	0.05	$ 5.5
TOTAL	196	$202.0	0.51	$1,026.2

1/ SOURCE: The Consequences of Electronic Funds Transfer, Table 4-7, p. 57. National Science Foundation. Research Applied to National Needs. NSF-0844, June, 1975.

2/ Assuming 0.5¢ per transaction rounding gain to merchant.

Those firms selling products that require the calculation of sales tax will encounter difficulties compounding the process of rounding. Laws in many states (e.g., Colorado statute 34-26-108) now require that the retailer neither undercollect nor overcollect sales tax from the consumer. In those states not employing a five or ten percent tax rate, a "fair" collection of tax would appear to be difficult and might require alternative tax legislation. Potential problems encountered in tax collection from the viewpoint of one a surveyed tax administrator are highlighted by his comment:

> "If an item retails for $1.44, addition of the $0.4 tax brings the transaction to $1.48. The retailer would probably charge $1.50. What portion of the amount is tax? The current tax is 5¢ on sales totaling $1.45 to $1.74. Does the retailer owe the state 5¢ or 4¢? When we audit how would we differentiate sales where an extra amount was added to accomodate the coinage change?"

Elimination of the cent coin would marginally reduce the potential for slugging in automatic merchandising. However, the demise of penny gum vending would be hastened.

2.5 Comparison of the Impacts of Candidate Alternatives to the Copper Cent

The three candidate alternatives to the present copper cent have very different impacts on the producers, distributors, and users of U.S. coinage. In this section, the potential impacts and the costs associated with each alternative are summarized.

2.5.1 Impacts of Alternative Strategies

Both negative and positive impacts will result with the implementation of any of the three alternative strategies for alleviating the cent dilemma. These impacts are summarized here.

Alternative 1: Change the Material Composition of the Cent Coin to Aluminum

POSITIVE IMPACTS

- Protected seigniorage
- Shipping and handling weight reduced

NEGATIVE IMPACTS

- Increased production requirements as aluminum cents replace hoarded copper cents
- Cent coins cannot be counted by weight while aluminum cents cocirculate with copper cents
- Lightweight coin may jam vending machines
- Popular perception of lightweight coins as a valueless "nuisance" may increase cent attrition rate, requiring even greater production of cents and consequently expanded Mint capacity

Alternative 2: Addition of a Two Cent Coin

POSITIVE IMPACTS

- Reduced coin production: lower Mint capacity and storage requirements
- Gain in seigniorage
- Provides transition to elimination of the cent with less rounding impact

NEGATIVE IMPACTS

- Not compatible with existing coin processing equipment - requiring modification or replacement of equipment in the field
- Increase potential for clerical error with handling of additional coin in retail transactions
- Additional complexity of coinage system to general public
- Lightweight coin may jam vending machines

Alternative 3: Elimination of the Cent

POSITIVE IMPACTS

- Reduced Mint production costs
- Reduced costs of shipping, storage, handling cost to Federal Reserve banks, commercial banks, and retail merchandising firms
- Free funds tied up in cent inventories for commercial banks and retail firms
- Cost savings passed on to consumers

NEGATIVE IMPACTS

- Loss of cent seigniorage
- Immediate reduction in force of more than 530 persons
- $2 million annual loss in revenue to trucking industry
- $14 million annual loss in revenue to strip manufacturers
- Inflationary impact from rounding of transactions
- Retraining on rounding for personnel handling cash transactions
- Would effect accounting system based on $0.05 for cash transactions, $0.01 for check and credit transactions
- Decreased pricing flexibility
- Sales tax legislation required

2.5.2 Cost Impacts

Two types of direct costs are compared for each option. The transition costs are the initial one-time or unique costs which are associated with a conversion from the present system to an alternative system. These are considered to be the costs incurred from 1978 through 1980 and are compared in Table 7-17. The long-term costs are those which would be mainly incurred after the transition. A comparative analysis of those costs to 1990 is presented in Table 7-18.

These costs include the manufacturing and distribution costs to the Mint, and the capital investments required for Mint capacity expansion; the costs to the banking system and retail firms for processing coins, modifying equipment and altering business practices in the event of any change. Presented also are the costs anticipated for the automatic merchandising industry to handle an aluminum one or two cent coin.

This rounding cost is not a direct cost to the coinage system, and is consequently not included in the total cost for eliminating the cent. This cost is indirect in that it is equivalent to a "transfer" from consumers to retail firms, which might in turn serve to offset transition or other relevant costs incurred by retail firms, resulting in little

Table 7-17

Comparison of Costs Incurred by Affected Groups for One Cent Alternatives: Net Present Value of Total Costs from 1978 Through 1980 1/
(Million Dollars)

Category of Costs	Present Cent	Aluminum Cent	2 Cent Introduction	Cent Elimination
Treasury				
Manufacturing and Distribution Costs	389	145	163	129
Capital Costs	72	94	3	
Federal Reserve and Commercial Banks				
Coin Processing	41	71	103 2/	17
Retail Firms				
Coin Processing	171	188	296 2/	40
Automatic Merchandisers				
Coin Processing		34	50	
Consumers				1,026 1/
TOTAL	673	532	615	186

1/ Costs due to potential loss from rounding not included in total since it may be considered a transfer from consumers to retail firms.

2/ Includes costs for equipment modification or replacement.

Table 7-18

Comparison of Costs Incurred by Affected Groups for One Cent Alternatives: Net Present Value of Total Costs from 1978 Through 1990 1/
(Million Dollars)

Category of Costs	Present Cent	Aluminum Cent	2 Cent Introduction	Cent Elimination
Treasury				
Manufacturing and Distribution Costs	3,524	880	855	403
Capital Cost	130	163	66	
Federal Reserve and Commercial Banks				
Coin Processing	300	438	347 3/	61
Retail Firms				
Coin Processing	1,099	1,130	1,218 3/	118
Automatic Merchandisers				
Coin Processing		32	47	
Consumers				1,026 2/
TOTAL	4,053	2,643	2,533	582

1/ Net present value discounted at 5 percent to 1990.

2/ Cost to consumers due to potential losses from rounding of transaction was excluded from the total since it may be considered a transfer from consumers to retail firms.

3/ Includes costs for equipment modification or replacement.

or no "net" cost when considering the entire coinage system. Other indirect costs resulting in similar transfers with the elimination of the cent include the loss in annual revenue to the trucking industry and to strip manufacturers. These costs imply "losses" to the industries in question, while indicating "gains" for the U.S. Mint. The manner in which these indirect costs will cancel out for the entire system is not readily quantifiable; consequently these costs were excluded from the totals.

The transition costs summarized in Table 7-17 and the discounted direct total costs to 1990 shown in Table 7-18 strongly favor elimination of the cent as the least costly of the one cent alternatives. Obviously, elimination of the cent is least costly because no capital expenditures are required and manufacturing and distribution requirements are reduced.

The transition costs for elimination of the cent are approximately one-third the level of those associated with the aluminum cent, the closest alternative. The present value of the long-term direct costs of cent elimination, $582 million, are approximately 25 percent of those for the aluminum cent or the 2 cent options. The costs for those two alternatives are similar at $2.5 billion, and are approximately 60 percent of the level for the present cent.

Table 7-19 compares the annual seigniorage to the Mint for each alternative. The change in composition of the cent to aluminum yields the highest seigniorage with a present value over the period of $1,603 million, compared with a deficit of $419 million for the present cent.

Each of the cent alternatives will exert very different cost impacts on the various sectors of the coinage system. If the copper cent is maintained, the U.S. Department of the Treasury will bear the primary cost burden as the price of copper rises. With the other three options, the total costs through 1990 are one-third as great for the Treasury, but higher for some of the other sectors. The lowest cost option for the Federal Reserve and commercial banks and retail firms is the elimination of the cent. Both a change in the composition of

Table 7-19

Annual Seigniorage For One Cent Alternatives
(Million Dollars)

Year	Present System	Aluminum Cent Coin	Two Cent Coin	Elimination of the Cent
1978	18	134	118	123
1979	13	132	218	117
1980	4	134	113	117
1981	0	175	120	120
1982	-11	160	133	123
1983	-25	180	141	126
1984	139	158	153	126
1985	-67	170	161	129
1986	-81	182	172	133
1987	-94	196	185	133
1988	-122	210	196	134
1989	-146	223	174	136
1990	-177	233	173	138
TOTAL	-727	2,287	1,967	1,657
AVERAGE	-56	176	151	127
NET PRESENT VALUE 1/	-419	1,603	1,357	1,185

1/ Net present value discounted at five percent to 1990.

the cent to aluminum and the introduction of a two cent coin would result in higher costs to these sectors than maintaining the copper cent. The automatic merchandising industry would incur costs with the introduction of an aluminum one or two cent coin, and although consumers might experience some inconvenience with the aluminum one or two cent coins, the elimination of the cent will exert the most significant impact on them.

The option that incurs the least costs for the entire system is the elimination of the cent with a cost of $582 million (net present value) to 1990. This figure does not include the rounding costs for the stated reasons. However, even if it were included in this total, elimination of the cent would still be the least-cost option.

3.0 IMPACTS OF INTRODUCING A SMALLER ONE DOLLAR COIN

The impacts of introducing a more conveniently-sized one dollar coin are not of the same type or magnitude as the impacts that would result from implementing any of the cent alternatives. They are also less easily quantified. The demand for the dollar coin, and the resulting production and manufacturing requirements are less reliably projected than those for the cent options: the manner in which the coin will circulate is not as predictable and will significantly depend upon the response of the automatic merchandising industry. If the industry's current enthusiasm for the introduction of the smaller coin translates into an expanded vending market that accepts the new coin for purchases, the coin may be widely accepted within a relatively short period of time. The extent of this acceptance and the length of time involved in transition will be almost wholly the responsibility of the automatic merchandising industry.

3.1 Costs

The incremental costs to the U.S. Mint for producing a conveniently-sized one dollar coin will be minimal. The costs to other sectors will only be marginally greater. Commercial banks and retail firms were requested through the survey of coin users to estimate the personnel

and equipment costs that would be incurred in accommodating a change to a more conveniently sized one dollar coin. Most (70.7 percent) of the commercial banks indicated that zero or minimal personnel costs would be incurred, although only 46.7 percent expected to incur zero or minimal equipment costs. Similarly, most (70.7 percent) of the retail firms responded that zero or minimal personnel costs were anticipated, with 63.1 percent anticipating zero or minimal equipment related costs. Responding banks expecting to incur costs in a transition period after the introduction of the smaller one dollar coin comprised 27.6 percent of those surveyed. The estimated costs ranged from $100 to $325,000, with a total cost of $1.9 million. To the extent that these cost estimates are based on deposits, an estimated cost of $3 million may be incurred by commercial banks. Only 8.7 percent of the retail firms surveyed estimated non-zero costs if a smaller one dollar coin were to replace the current coin. These cost estimates ranged from $10 to $3,000,000 and totalled $3.7 million. To the extent that the retail firm's costs estimates are based on retail sales, an estimated cost of $13 million may be incurred by these firms.

The costs to modify coin processing equipment will be similar to those estimated earlier for the introduction of a two cent coin. These costs were $125 million for retail firms, $53 million for commercial banks, and $0.5 million for the Federal Reserve banks and branches.

3.2 Impacts

The types of impacts anticipated with the introduction of a smaller one dollar coin are as follows:

POSITIVE IMPACTS

- One dollar coin will result in cost savings to government if consumers substitute coins for bills
  - -- bill costs 1.2¢ and has an average life of 18 months
  - -- coin may cost 3.0 to 4.0¢ but has average life of 15 years
- Reduction in manufacturing costs for Treasury

- Conveniently-sized one dollar coin will expand the market opportunities of the vending industry
- One dollar coin will no longer be a commercial oddity

NEGATIVE IMPACTS

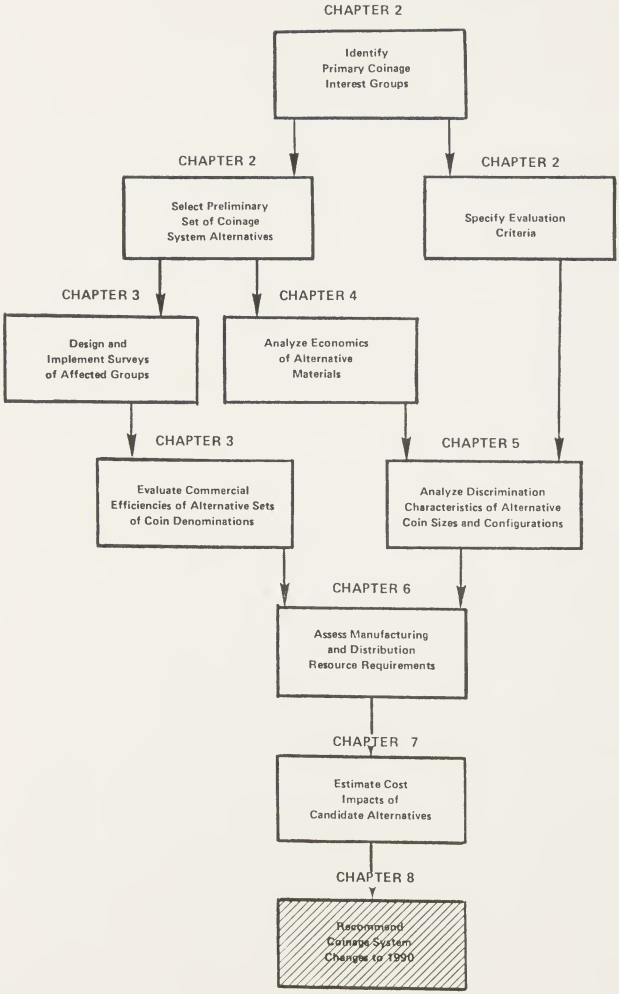
- Costs will be incurred in adapting to a new-sized coin
- If coin fails to circulate, there will be a cost to those firms that invested in adapting equipment
- Although present half dollar and dollar coins do not circulate freely, some consumers may react negatively to their elimination

3.3 Summary

The present one dollar and half dollar coins do not circulate readily. They are at best anachronisms, and continuing to mint them will serve no useful purpose other than satisfying numismatic demand. A change in size would at least allow the potential for ready circulation. As discussed in earlier chapters, changing the sizes of both coins would not facilitate discrimination since the quarter, half dollar and dollar coins could not be easily distinguished by their sizes. Therefore, the one dollar coin was selected as the most feasible candidate for a change in size. This change will effectively render half dollar coins obsolete and the Department of the Treasury should terminate their production subsequent to the introduction of the small dollar coin.

The one dollar coin may reduce the future requirements for one dollar notes. However, this coin should not be introduced as a substitute for the note; it is not a convenient substitute in all situations, and the public may justifiably oppose this strategy. After the coin is introduced, ther may be a time lag before the coins are popularly accepted as numismatic demand is satisfied, and vending and coin processing machines are adapted for the new coin. If the one dollar coin does circulate freely, intentional substitution for one dollar notes may begin.

The illusion that the introduction of this coin will imply a corresponding price increase in products sold through automatic merchandising is not based on sound economic reasoning. The one dollar coin will serve to expand the market for vended products and will make some purchases more convenient. For example, a one dollar coin could be used instead of three quarters for purchasing a $0.75 pack of cigarettes. However, the existence of the additional coin alone would not cause a price increase in the product.


CHAPTER 2
Identify Primary Coinage Interest Groups
CHAPTER 2
Select Preliminary Set of Coinage System Alternatives
CHAPTER 2
Specify Evaluation Criteria
CHAPTER 3
Design and Implement Surveys of Affected Groups
CHAPTER 4
Analyze Economics of Alternative Materials
CHAPTER 3
Evaluate Commercial Efficiencies of Alternative Sets of Coin Denominations
CHAPTER 5
Analyze Discrimination Characteristics of Alternative Coin Sizes and Configurations
CHAPTER 6
Assess Manufacturing and Distribution Resource Requirements
CHAPTER 7
Estimate Cost Impacts of Candidate Alternatives
CHAPTER 8
Recommend Coinage System Changes to 1990

Chapter 8

Recommendations

1.0 INTRODUCTION

Transition from the present U.S. coinage system is inevitable. Producing all the coins required to 1990 would place untenable resource and cost burdens on U.S. citizens relative to the benefits of this strategy. The problems that exist with currently-minted coinage are the disproportionate requirements for one cent coins, and the failure of the half dollar and one dollar coins to circulate readily. Through the course of this report, the alternative solutions to each of these problems have been analyzed and discussed in terms of their relative feasibility. In this chapter, strategies for resolving these dilemmas are recommended.

2.0 ALTERNATIVES TO THE COPPER CENT

If the current coinage set is maintained, the Mint must more than double its coin manufacturing capacity by 1990. Over 90 percent of that capacity would be utilized in manufacturing copper cent requirements. The majority of those cents produced would only be replacements for attrition. The alternatives found to be the most effective solutions to this dilemma include: changing the material composition of the cent from copper to aluminum; introducing an aluminum two cent coin to cocirculate with the copper cent; and eliminating the one cent coin entirely.

RTI's recommendation is that production of the cent coin be terminated by 1980. This selection is based on the relative cost and acceptability of this option when compared with the other two alternatives. With each of the other options, the Mint would have to expand its capacity, requiring extensive capital investments in manufacturing equipment and production facilities, to produce coins that would, with continuing inflation, soon be valueless. Resolution of the dilemma at that time

would require ceasing production of the valueless coins and would result in displacement of the facilities that had been constructed, the capital resources that had been acquired, and the employees who had been hired during the interim.

Eliminating the cent was generally viewed as unacceptable by the surveyed groups of coin users, due to the perceived impacts on commercial transactions and uncertainty about inflationary and administrative effects. Their attitude also seems to be a function of their resistance to change. Change, however, is inevitable for the cent and its elimination is deemed the most desirable alternative.

Barring its implementation, only a marginal cost differential exists between the options of introducing an aluminum two cent coin and changing the material composition of the one cent coin to aluminum. Of those two options, the latter is preferred since it would be less complicated for the coinage system as a whole.

Immediate implementation of a strategy to eliminate the cent is not necessary. Positive seigniorage for the copper cent is projected to 1981, although the total cost of manufacturing, distributing, storing, and providing cents for commerce already exceeds the coin's face value. However, total coin requirements with the present mix of denominations will exceed manufacturing capacity by 1980. Unless positive action is taken soon to expand capacity, a cent shortage will begin by 1980 or a suboptimal production strategy will be necessary.

Unless copper prices rise to an unanticipated level, the strategy to eliminate the cent may be implemented as late as 1980 without incurring excessive costs. Foregoing capacity expansion at present is tacit recognition of the inevitability of change without declaration of the intent to change.

Public awareness of an intent to eliminate the cent will manifest itself in accumulation of cent inventories by businesses and cent hoarding for speculative purposes by individuals. This awareness will be heightened by any request for Congressional action to change the present coin system by the Department of the Treasury.

Recognizing the interim effects of cent hoarding, RTI recommends that the Department of the Treasury request Congressional approval to terminate manufacturing cent coins prior to 1979. A phased reduction rather than immediate termination of cent production is also recommended to smooth the transition and to allow for an orderly reduction and consolidation of Mint production resources.

3.0 THE ONE DOLLAR COIN

At present, commercial utilization is poor for the half dollar and nonexistant for dollar coins, due to their cumbersome sizes and the ready availability of convenient substitutes (two quarters for the half dollar and a dollar note for the dollar coin). The alternatives are to continue manufacturing the present coins or to reduce the size of or eliminate, the half dollar and/or the dollar coins.

RTI recommends that legislation be sought to eliminate the half dollar from circulation and reduce the size of the dollar coin. The new dollar should be of a cupronickel clad or copper material, round, 26.54 mm. in diameter, 2.03 mm. thick, and possess a distinctive edge characteristic (to be designed by the Bureau of the Mint) for mechanical discrimination. These specifications represent the consensus of the primary manufacturers of coin validating processing equipment as being the optimum for coin discrimination.

The Department of the Treasury should conduct a vigorous campaign to educate the public about the changes prior to and simultaneous with the introduction of the small dollar. However, initial success of the coin in circulation will depend heavily on the speed and extent of the automatic merchandising industry's response. The coin will circulate successfully only if it provides a means to effectively and conveniently broaden the transaction capabilities of consumers. It should not be forced into circulation by artificial restriction of the availability of one dollar notes.

4.0 OTHER COINAGE CHANGES

No other changes in the size, configuration, or denomination of U.S. coins were determined to be warranted due to the acceptability and efficiency of the remaining coins--and the capital commitments of the public and private sectors to them. However, one other change warrants an additional analysis.

No direct usage exists for the scrap material from the manufacture of clad coinage. A portion of this 93 percent copper-7 percent nickel scrap could be used economically to manufacture the nickel coin which is now made of a 75 percent copper-25 percent nickel alloy. Replacement of the present material with the clad scrap would utilize the scrap material and would result in a less costly nickel. The coin's appearance would have a reddish cast that would be aesthetically acceptable, and the coin would be compatible with existing coin processing equipment.

On the basis of the economic gains and material handling advantage, immediate further experimental testing of the nickel alternative is recommended.

5.0 FACILITY UTILIZATION

If the recommendations to eliminate the cent and half dollar and reduce the size of the dollar are implemented, the Bureau of the Mint will have manufacturing capacity in excess of its requirements to the year 2000. The production of coin for circulation should then be consolidated at a single Mint facility; preferably the Philadelphia Mint; which is the newest and largest U.S. Mint facility in operation.

With excess capacity, the Bureau of the Mint can continue its operation as a fully vertically integrated manufacturing enterprise. However, if elimination of the cent is deemed an unacceptable alternative, then the Mint should seriously consider foregoing the manufacture of intermediate materials and products in order to increase the resources available for its mandated tasks: the manufacture of coins and coin dies. Items manufactured by the Mint which could be purchased from the private sector include: coin bags; coin boxes; penny bronze; cupronickel and clad strip; and, to a lesser extent, commemorative medals.

6.0 TECHNOLOGICAL ASSESSMENT

The Office of Technology of the Bureau of the Mint has done an excellent job with limited resources of assessing requirements and evaluating alternatives for technological change in the dynamic environment of the past decade. The future environment is anticipated to be no less dynamic. Evaluations of manufacturing and metallurgical technology will require ongoing assessments of new potentials for coinage. In order to maintain the necessary capabilities for technolgical assessment it is recommended that the resources of the Office of Technology be expanded by the addition of at least two analysts.

Appendix A

Coinage Study Advisory Panel and the Evaluation Criteria

Advisory Panel

Name	Title	Organization
Mr. Harry E. Hughes	Head of Coin Station and Physical Design Department	Bell Telephone Laboratories
Mr. Joseph L. Levasseur	Executive Vice President and General Manager	Coin Acceptors
Mr. Fred Schlegel	President	Standard-Reis International, Inc.
Mr. A. R. Buchholz	Assistant Director of Engineering	Brandt, Inc.
Mr. Kit Pennell	Product Manager	The Vendo Company
Mr. J. N. Sturdy	Vice President, Engineering	NRI (National Rejectors)
Mr. Edward C. Rochette	Executive Director	American Numismatic Association
Mr. Peter McCloskey	President	Computer & Business Manufacturers Association (CBEMA)
Mr. James E. Lodge	Director of Operations and Automation	American Bankers Association
Mr. Don Ring	Assistant Director of Banks Operations Division	Board of Governors of the Federal Reserve System
Mr. Thomas E. Gainor	Senior Vice President	Federal Reserve Bank
Ms. Margo Russell	Editor	Coin World
Mr. G. Richard Schreiber	President	National Automatic Merchandising Association (NAMA)
Mr. Frank H. MacDonald	Deputy Director	Bureau of the Mint
Dr. Alan J. Goldman	Assistant Director for Technology	Bureau of the Mint
Mr. George G. Ambrose	Office of Production	Bureau of the Mint
Mr. Fred Heiman	President	Mars Money Systems
Mr. Joseph F. Carroll	Attorney-Real Estate	F. W. Woolworth Co.
Mr. Norman Strunk	Executive Vice President	U.S. League of Savings Associations

RESEARCH TRIANGLE INSTITUTE

U.S. COINAGE SYSTEM STUDY

Advisory Committee Polling Instrument

Respondent's Name: _____

Respondent's Title: _____

Address: _____

_____

_____

Telephone Number: _____

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

A primary objective of the U.S. coinage system study is to identify and assess alternatives to the existing coinage system which facilitate commercial transactions at a reasonable cost. Please specify alternatives (individual changes or combinations of changes in the size, shape, materials composition, weight, denomination, or other characteristics of U.S. coins) which should be included in the analysis of alternatives during the study.

(Please attach additional sheets if necessary.)

Please list the specific and general criteria or standards for coins which should be considered in any evaluation of alternatives to the existing coinage system and which are important to your organization.

(Please attach additional sheets if necessary.)

PROBLEM AREA I

Penny demand has increased 300 percent in 10 years to the current level of 9 billion per year. Presently, pennies account for 80 percent of total coin production. By 1990, penny demand may exceed 25 billion per year.

ACTION ALTERNATIVES

A. Maintain the existing mix of coin denominations and compositions, and expand production and distribution capacity to meet the requirements for pennies.

B. Replace the 95% copper – 5% zinc penny with an alternative material.

C. Add a 2-cent coin to the existing denominations to reduce the projected number of pennies needed for commercial transactions.

D. Eliminate the penny denomination from circulation.

PROBLEM AREA II

The existing one-half dollar and one dollar coins circulate poorly and are not often used in cash transactions.

ACTION ALTERNATIVES

A. Maintain the existing mix of coin denominations and compositions.

B. Eliminate the one dollar and/or the one-half dollar coins from circulation.

C. Replace the existing one dollar coin with a smaller, more conveniently sized one dollar coin and eliminate the one-half dollar from circulation.

CRITERIA FOR EVALUATING COINAGE SYSTEM ALTERNATIVES

A. **COMPATABILITY WITH EXISTING EQUIPMENT** – The extent to which coin alternatives may be processed in existing coin validators, counters, sorters, changers, packagers, and other processing or storage equipment.

B. **COST** – Total manufacturing and distribution costs of the coin system.

C. **DURABILITY** – The ability of the coins to withstand wear resulting from use in circulation.

D. **EDDY CURRENT DISCRIMINATION** – The degree to which a coin may be discriminated from other coins or slugs in a magnetic field.

E. **AESTHETIC APPEARANCE** – Attractiveness of form, design, and color; susceptability to tarnishing or corrosion.

F. **COMMERCIAL EFFICIENCY** – The extent to which the mix of coin denominations are convenient and useful for commercial transactions.

G. **MECHANICAL DISCRIMINATION** – The degree to which a coin may be discriminated from other coins or slugs through tests of its mechanical properties.

H. **PUBLIC ACCEPTABILITY** – Convenience to individuals; based on coin size, weight, and ease of manual or visual discrimination among denominations.

I. **SEIGNIORAGE PROTECTION** – The extent to which the face value of a coin exceeds its material plus manufacturing cost.

COINAGE STUDY ADVISORY COMMITTEE
RATINGS OF EVALUATION CRITERIA

Respondent's Name _____ Mailing Address _____

Respondent's Title _____ _____

Telephone Number _____ _____

Please estimate the relative importance of the nine criteria for evaluating the Problem Area I action alternatives by completing the following steps:

1. In column A, rank the nine criteria according to their order of importance. (Assign a rank of 9 to the most important criterion, 8 to the next most important criterion, through 1 for the least important criterion.)
2. In column B, assign a weight of 100 points to the most important criterion. On a scale ranging from 100 for the most important to 0 for any criterion with no importance, please assign weights to indicate the relative importance of each criterion.

REPEAT THE ABOVE PROCESS FOR PROBLEM AREA II.

ASSESSMENT FOR PROBLEM AREA I – PENNY REQUIREMENTS

Criteria	A Rank Order	B Relative Weights
A. Compatibility With Existing Equipment		
B. Cost to Manufacture and Distribute		
C. Durability		
D. Eddy Current Discrimination		
E. Aesthetic Appearance		
F. Commercial Efficiency		
G. Mechanical Discrimination		
H. Public Acceptability		
I. Seigniorage Protection		

ASSESSMENT FOR PROBLEM AREA II – DOLLAR COIN CIRCULATION

Criteria	A Rank Order	B Relative Weights
A. Compatibility With Existing Equipment		
B. Cost to Manufacture and Distribute		
C. Durability		
D. Eddy Current Discrimination		
E. Aesthetic Appearance		
F. Commercial Efficiency		
G. Mechanical Discrimination		
H. Public Acceptability		
I. Seigniorage Protection		

Table A-1

Rankings of the Relative Importance of Criteria for Evaluating Coinage System Alternatives[1]

Criterion	Rank for Minor Coin Denomination Alternatives	Rank for Dollar Coin Alternatives
Public Acceptability	1	1
Commercial Efficiency	2	2
Compatibility with Existing Equipment	3	8
Durability	4	5
Cost to Manufacture and Distribute	5	7
Seigniorage Protection	6	9
Aesthetic Appearance	7	4
Mechanical Discrimination	8	6
Eddy Current Discrimination	9	3

[1] Rankings from 1 for the most important criterion to 9 for the least important criterion.

Appendix B

Survey Methodology and Example of a Survey Questionnaire

Appendix B

Survey Methodology

1.0 INTRODUCTION

Retail businesses, banks, and other industries or groups of persons may be affected by any changes in coin denominations, configuration, or materials content. Market research is required in order to measure the relative impacts of alternative changes on the groups most likely affected by modifications to the coin system. The method utilized to conduct market research in this context was to present to users several proposed changes in the coinage system and elicit their preferences and their reactions to potential changes. This method was accomplished through the use of questionnaires mailed to members of several target groups of coin users. This appendix summarizes the process of conducting this market research.[1/]

2.0 TARGET POPULATIONS OF COIN USERS

While nearly all individuals and business firms use coins to some extent in conducting economic transactions, the organizations which would incur the greatest impact from changes in the coinage system are those which employ automatic equipment for receiving, processing, and distributing coinage. Automatic coinage processing systems lack flexibility and can accommodate changes less easily than manual systems. Thus, the organizations which constituted the primary subjects of the market research were those businesses which conduct large volumes of low price cash transactions in few locations or in a number of relatively homogeneous facilities dispersed across a wider geographic area. Organizations which process large volumes of coinage at a single location are most likely to employ automatic coin processing equipment, and

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[1/] For a detailed presentation of the market research, see M. Anne Hill, Analysis of User Responses to Candidate Changes in the U.S. Coinage System, Research Triangle Institute Memorandum RM-26U-1133-5, prepared for the U.S. Department of the Treasury, the Bureau of the Mint, May 1976.

organizations whose basic facilities are replicated in a number of sites, generally use similar cash registers and coin changers throughout their corporate systems.

The significance of the impact of a change is perhaps as varied as the sectors that are involved. These sectors are defined here to include retail merchandising firms, commercial banks, automatic merchandising firms, manufacturers of coin processing equipment, transportation system operators, and tax administrators. Each of these target groups of coin users will be discussed in the following sections.

The impact of alternatives to the existing coinage system on individual consumers and their preferences for changes were not addressed in this study. However, consumer attitudes and preferences are significant factors which will be incorporated into any changes implemented by the Department of the Treasury.

2.1 Retail Merchandising Firms

Retail firms were surveyed to ascertain the technical and administrative impacts of changes into the U.S. coinage system. Increasing numbers of retail stores and fast food outlets are utilizing complex registers to compute amounts due and change as well as to facilitate bookkeeping and inventory control. In addition to standard cash registers, machines which total orders by mark-sensing, magnetic card, and keying are being used. Consequently, retail establishments constitute a segment of users that were of special interest in studying the impact of changes in the coinage system. For purposes here, retail firms, drug stores, food stores, and fast food outlets comprise this group of coin users.

2.2 Commercial Banks

Commercial banks were included in the survey effort since they are users of various types of equipment related to counting or sorting coins. Banks constitute a critical link in the coinage delivery system. However, the primary purpose of contacting this segment of affected users was to solicit indications of anticipated problems, likely changes that the introduction of new coins would create, and their impressions of consumer acceptance of new coins.

2.3 Automatic Merchandising Service Firms

Automatic merchandising firms constitute the unique industry of businesses relying upon person to machine transactions. Significant issues affecting this industry include the potential markets for automatic merchandising transactions associated with alternative coin denominations and the potentials for spurious vends or jamming that may be associated with different coin configurations.

2.4 Manufacturers of Coin Processing Equipment

The preferences and concerns of the manufacturers of coin processing equipment are compatible with those of the automatic merchandising industry in that they manufacture the equipment necessary for automatic merchandising transactions. This industry includes producers of all types of coin equipment that validate, sort, count, or make change for coins. Since the existing coin processing equipment is designed within close tolerances to identify and process denominations of U.S. coins in a specific manner, any changes in coin denominations or configurations may significantly impact the industry. As with the automatic merchandising firms, the manufactuers of coin equipment are concerned about the compatability of coin alternatives with existing equipment and in the event of incompatibility, the extent and cost of necessary modifications. For the manufacturers of coin equipment, alternatives to the existing system create an ambivalent reaction. On the one hand changes would stimulate additional sales associated with replacement of existing equipment. On the other hand, changes would create the necessity for additional methods of discrimination for coin processing. For these reasons the preferences and attitudes of the manufacturers of coi equipment toward alternatives to the existing coinage system are significant factors.

2.5 Transportation Systems Operators

Transportation Systems Operators handle large numbers of coins in the collection of transit fares. Fare collection is often implemented through the use of automatic merchandising. Consequently, this segment of coin users was contacted to ascertain the impact that changes in the coinage system would have on transportation fare collection.

2.6 State Departments of Revenue

The State Departments of Revenue are responsible for the administration of state sales taxes, and are aware of potential impact on sales tax collection that would result from coinage changes. This group was contacted with specific reference to the possible elimination of the one cent coin, and/or the introduction of a two cent coin.

2.7 Other Affected Groups

Other groups which have a special interest in specific attributes of the U.S. coinage system were also contacted to solicit their preferences for changes and the potential impacts of candidate changes. These groups include organizations representing visually impaired persons, who are concerned about physical discrimination of alternatives; numismatic organizations, which are interested in distinguishing characteristics of coins; and medical organizations, which are concerned with potential health hazards of alternatives.

Since the numbers of special interest groups were small or were concerned with a specific aspect of the coinage characteristics, a limited number of representative groups were contacted in telephone and personal interviews to solicit their input. The concensus of their opinions with respect to the issues of interest were incorporated into the survey conclusions where possible.

3.0 DESIGN OF THE SURVEY INSTRUMENT

The survey instrument was designed to elicit responses which would provide information relevant to recommendations for an ideal coinage system. Of specific interest was how each major group of coin users would be affected by changes in the U.S. coinage system, such as the addition or deletion of a coin denomination, or by a change in the size, shape, weight, or material composition of existing denominations. Other information of interest for assessing the impacts of changes included the numbers and types of coin processing equipment used by the target groups, as well as alternative measures of each respondent's size, such as the volume of sales, or the number of branch stores.

An individual questionnaire was designed for each of six target groups. The final design of each of these questionnaires was accomplished after pretesting the initial questionnaire with representatives of each group. An example questionnaire follows the text in this appendix.

4.0 SAMPLE SELECTION

For this study a list of all public and private organizations which handle U.S. coins, stratified by location, type, and size, would have comprised the ideal sampling frame. Such a list does not exist and would have been unduly costly to construct. As an alternative approach, industries whose quantity and type of commercial transactions warranted the use of automatic coin processing equipment were identified by Standard Industrial Classification (SIC) code.

To insure maximum coverage of potentially affected industries, within the time and cost constraints of the project, the sampling frame was further constrained to include only those firms with a net worth over $1,000,000 for each industry except retail banking and automatic merchandising.

The sampling methodology can be termed a systematic, random selection process within the defined sample units which consisted of firms in single or multiple SIC codes.

From the list of 1,580 firms engaged in nondurable goods retail sales in the Dunn and Bradstreet Million Dollar Directory, a sample of 206 retail firms were selected for the mail survey. The firms named on a list of 35 leading general merchandising chains in 1973, defined as those chains with sales above $200,000,000, were all included in the sample. The remaining 171 firms were selected by a systematic sampling process with a random start from the alphabetical list within each SIC code from the Million Dollar Directory. Comparable sales figures were recorded for each firm in the sample to facilitate statistical analysis.

The impacts of changes on commercial banks were of particular interest in the survey. Initially, the leading 100 banks, measured in terms of total deposits, were selected. Then 105 other banks were

selected in a systematic sample from a random start in Polk's Bank Directory for 1975. Data for bank deposits were recorded for each bank. Further specification by location was not considered necessary to produce a reliable sample of commercial banks from which to draw inferences about impacts.

The National Automatic Merchandising Association Members Directory 1975 was the source for data on automatic merchandising service companies. Fifty nine companies were selected in a systematic sample with a random start from the list of member companies.

A list of 50 local and suburban transit companies provided by the American Public Transit Association constituted the sample for the transit industry. A list of the tax administrators in each of the states was provided by the National Association of Tax Administrators.

5.0 THE ADMINISTRATION OF THE SURVEY INSTRUMENT

The administration of the survey industrument included an initial mailing of the appropriate questionnaire and cover letter to each of the six target groups of coin users. The initial mailing dates for each target group are included in Table B-1. The questionnaire was addressed to the chief executive officer of each firm. In order to achieve a higher response rate, a second questionnaire was mailed to those potential respondents (in all groups except the State Departments of Revenue) who had not returned the first questionnaire within approximately three weeks of the initial mailing date. Each potential respondent who had not returned a questionnaire within one month after the second mailing was then sent a mailgram urging participation in the survey.

Recording of data from incoming questionnaires ceased March 22, 1976 for all groups of respondents except the State Departments of Revenue. Information was finalized for this group on April 9. The response rate for each group is included in Table B-1. As may be seen in this table, the response rates were highest for commercial banks. This is not suprising, however, since commercial banks are a primary link in the coinage distribution network and, as such are more interested in coin configurations and denominations.

Table B-1

Survey Response Rates

Industry	Mailing Date of Initial Questionnaire	Number of Potential Respondents	Usable Responses	Response Rate (percent)
Retail Merchandising Establishments	1-6-76	370	184	49.7
Retail Firms	1-6-76	206	94	45.6
Drug Stores	1-6-76	50	26	52.0
Food Stores	1-6-76	60	35	58.3
Fast Food Outlets	1-6-76	54	29	53.7
Commercial Banks	1-6-76	205	167	81.5
Automatic Merchandising	1-6-76	102	54	52.9
Coin Equipment Manufacturing	1-9-76	24	16	66.7
Transportation System Operators	2-13-76	50	20	40.0
State Departments of Revenue	3-16-76	51	38	74.5
TOTAL		802	479	59.7

Cover Letter and Questionnaire for Retail Firms

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220

OFFICE OF
DIRECTOR OF THE MINT

Under contract to the U.S. Bureau of the Mint, Research Triangle Institute (RTI) is conducting a comprehensive review of U.S. coinage requirements to 1990. The study has been initiated in response to recent unanticipated increases in coin demand, volatile market prices of coinage materials, and the constrained production capacity of the Mint. In the study RTI will address present and future coinage needs and assess the impact of alternatives in order to recommend positive changes in the coinage system to better facilitate commerce.

RTI is contacting representatives of public and private groups which could be affected by changes in the U.S. coinage system to determine their preferences for coinage alternatives and the impact of changes on their organizations. In this regard, surveys will be conducted of firms in the commercial banking, retail merchandising, automatic merchandising, and coin equipment manufacturing industries. Your firm was selected in a sample chosen to represent the interests and concerns of the retail merchandising industry with respect to the U.S. coinage system.

Please assist us in evaluating potential changes in the U.S. coinage system by completing the enclosed questionnaire and returning it to the Research Triangle Institute in the enclosed envelope. Thank you for your interest and participation in this effort. If you have any questions concerning the survey, please call David Stuart, RTI's project leader, at (919) 549-8311.

We look forward to your response and assistance in this important undertaking.

Sincerely,

Mary Brooks

Mary Brooks
Director of the Mint

Keep Freedom in Your Future With U.S. Savings Bonds

OMB No. 48-S75004
Approval Expires December 31, 1976

UNITED STATES COINAGE REQUIREMENTS

SURVEY OF RETAIL BUSINESS FIRMS

conducted by
Research Triangle Institute
Post Office Box 12194
Research Triangle Park, North Carolina 27709

Firm Name _____

Firm Address _____

Respondent's Name _____

Respondent's Title _____

Telephone Number _____

All information you provide will be absolutely confidential; the name of your firm will never be associated in any way with your individual answers. The information you provide will be released only in aggregate or statistical summaries.

Questionnaire I.D. Number _____

PLEASE ANSWER THE FOLLOWING QUESTIONS FOR ALL OF YOUR FIRM'S STORES OR BRANCH LOCATIONS.

1. Describe your retail firm's geographic market area.

   ☐ City (Name) _____

   ☐ State (Name) _____

   ☐ Nation

   ☐ Other (Describe) _____

2. How many branch stores or sites does your firm have for retail customer transactions? _____

3. Approximately how many sales clerks are employed by your firm? _____

4. For each of the following types of coin processing equipment, please estimate the number of units used by your firm.

Type of Equipment	Check Box If Not Applicable	Number of Units	Brand Generally Purchased
Automatic Cash Registers	☐	_____	_____
Coin Payer or Cashier	☐	_____	_____
		_____	_____
Coin Sorter	☐	_____	_____
		_____	_____
Sorter-Counter	☐	_____	_____
		_____	_____
Coin Packager	☐	_____	_____
Counter-Packager	☐	_____	_____
Other (Please Describe)	☐	_____	_____
_____		_____	_____
_____		_____	_____
_____		_____	_____

5. Should any coins currently minted and circulated in the U. S. be discontinued because they are no longer useful for commercial transactions?

(CIRCLE ONE)

No 1

Yes . . . . . 2→If yes, please circle the denominations which should be discontinued.

1¢ 5¢ 10¢ 25¢ 50¢ $1.00

6. Should any additional denominations of coins be introduced into circulation, because they would be useful for commercial transactions?

(CIRCLE ONE)

No 1

Yes . . . . . 2→If yes, please enter the new denominations in the boxes below.

_____ _____ _____

_____ _____ _____

7. Please rank the following combinations of coin denominations in terms of their potential value for commercial transactions in 1980 and in 1990. If you feel other combinations would be useful, please list them below and include in your ranking. (Assign a rank of 1 for most useful, 2 for next most useful, etc.)

Coin Denominations								Rank for 1980	Rank for 1990
1¢	2¢	5¢	10¢	25¢	50¢	$1.00	-	_____	_____
-	2¢	5¢	10¢	25¢	50¢	$1.00	-	_____	_____
-	-	5¢	10¢	25¢	50¢	$1.00	-	_____	_____
1¢	-	5¢	10¢	25¢	50¢	$1.00	-	_____	_____
1¢	-	5¢	10¢	25¢	50¢	$1.00	$2.00	_____	_____
-	-	5¢	10¢	25¢	-	$1.00	$2.00	_____	_____

Other combinations

__	__	__	__	__	__	__	__	__	_____	_____
__	__	__	__	__	__	__	__	__	_____	_____

8. How do you feel about discontinuing the penny, so that the smallest denomination in circulation is a nickel?

(CIRCLE ONE)

Highly favorable 1
Slightly favorable 2
Indifferent 3
Slightly unfavorable 4
Highly unfavorable 5

COMMENTS: _____

_____

9. How do you feel about the reintroduction of the $2.00 bill?

(CIRCLE ONE)

Highly favorable 1
Slightly favorable 2
Indifferent 3
Slightly unfavorable 4
Highly unfavorable 5

COMMENTS: _____

_____

10. After the $2 bill has been introduced in 1976, what mix of bills and/or coins will your sales clerks generally give as change to a customer making a 25¢ purchase with a $5 bill?

_____

11. Introduction of a 2¢ coin is being evaluated as a means to reduce the number of pennies needed. How do you feel about the introduction of a 2¢ coin?

(CIRCLE ONE)

Highly favorable 1

Slightly favorable 2

Indifferent 3

Slightly unfavorable 4

Highly unfavorable 5

COMMENTS: _____

_____

12. If a 2¢ coin is introduced, would you prefer that it be an additional denomination or a replacement for an existing denomination?

(CIRCLE ONE)

Additional . . . 1

Replacement . . 2 ——→ If so, what existing denomination should it replace?

_____

13. Please circle one number for each of the following categories to describe your preferences for the configuration of a 2¢ coin if such a coin is added to the current denominations.

A. PREFERRED DIAMETER (CIRCLE ONE)

Smaller than a 10¢ coin	1
Between the 10¢ and 1¢ coins	2
Same as the 1¢ coin	3
Between the 1¢ and 5¢ coins	4
Larger than the 5¢ coin	5
Other _____	6

B. PREFERRED SHAPE

Round -	1
Multi-sided -	2
Scalloped -	3
Round, with center hole -	4
Other _____	5

(diagram)

C. PREFERRED COLOR

Silver (like 25¢ coin)	1
Copper (like 1¢ coin)	2
Brass (yellowish)	3
Other _____	4

D. PREFERRED THICKNESS (CIRCLE ONE)

Thinner than the 1¢ coin	1
Same as the 1¢ coin	2
Thicker than the 1¢ coin	3
Other _____	4

E. PREFERRED EDGE

Reeded (like 25¢ coin)	1
Smooth (like 5¢ coin)	2
Other _____	3

(diagram)

F. PREFERRED WEIGHT

Present weight	1
Similar to 25¢ coin	2
Similar to 10¢ coin	3
Other _____	4

COMMENTS _____

_____

14. The existing $1 coin is not often used in cash transactions. Please circle one number for each of the following categories to describe your preference for a $1 coin which would be useful, assuming no other denominations are changed.

(CIRCLE ONE)

A. PREFERRED DIAMETER

Diameter of present $1 coins	1
Between the 25¢ and 50¢ coins	2
Between the 5¢ and 25¢ coins	3
Smaller than the 5¢ coin	4
Other _____ (describe)	5

B. PREFERRED SHAPE

Round -	1
Multi-sided -	2
Scalloped -	3
Round, with center hole -	4
Other _____ (diagram)	5

C. PREFERRED COLOR

Silver (like 25¢ coin)	1
Copper (like 1¢ coin)	2
Brass (yellowish)	3
Other _____	4

(CIRCLE ONE)

D. PREFERRED THICKNESS

Thickness of present $1 coin	1
Between the 25¢ and $1 coin	2
Thickness of the 25¢ coin	3
Thinner than the 25¢ coin	4
Other _____ (describe)	5

E. PREFERRED EDGE

Reeded (like 25¢ coin) -	1
Smooth (like 5¢ coin) -	2
Other _____ (diagram)	3

F. PREFERRED WEIGHT

Present weight	1
Similar to 25¢ coin	2
Similar to 10¢ coin	3
Other _____	4

COMMENTS _____

_____

15. If the 50¢ coin were eliminated, would any of your preferences for the configuration of a $1 coin be changed from those you specified above?

(CIRCLE ONE)

No 1

Yes . . . . . 2 ——→ If yes, please place a check mark beside your new preferences for each of the changed categories in question 14.

THE FOLLOWING QUESTIONS CONCERN THE IMPACTS THAT CHANGES IN THE U.S. COINAGE SYSTEM WOULD HAVE ON YOUR FIRM'S OPERATIONS.

SUPPOSE THE U.S. GOVERNMENT STOPS MINTING THE PENNY AFTER 1975 AND NO OTHER CHANGES IN COINS ARE MADE. *(Please answer questions 16 and 17 with respect to the impact of this change on your firm.)*

16. Would your firm implement any changes in clerical work processes or coin handling procedures?

(CIRCLE ONE)

No 1

Yes . . . . . 2 ——→ If yes, please describe the changes.

_____

_____

_____

17. Please describe any modifications (including total costs) which would be necessary for forms, vaults, and other equipment and facilities.

Equipment Type	Total Units of Equipment	Modification Cost Per Unit	Replacement Cost Per Unit	Total Cost to Bank

ANOTHER ALTERNATIVE IS THE ADDITION OF A 2 CENT COIN TO THE EXISTING DENOMINATIONS. SUCH A CHANGE COULD REQUIRE MODIFICATION OR REPLACEMENT OF COIN PROCESSING EQUIPMENT. *(Please answer questions 18 and 19 with respect to the impact of this change on your firm.)*

18. Would your firm be willing to purchase new coin cashiers or payers, and new sorter-counters to accommodate the change?

(CIRCLE ONE)

Yes . . . . . 1 ⟶ If yes, would your firm replace the existing equipment immediately, as it is depreciated, or otherwise?

_____

No . . . . . 2 ⟶ If no, what change in coin paying, receiving, and processing operations would your firm initiate?

_____

_____

_____

19. Please describe any modifications (including total costs) which would be necessary for forms, vaults, and other equipment and facilities.

Equipment Type	Total Units of Equipment	Modification Cost Per Unit	Replacement Cost Per Unit	Total Cost to Bank

20. What is the maximum number of dollars per unit that your firm would be willing to pay to modify its coin processing equipment to accommodate the 2¢ coin if new replacement equipment is not purchased. (Please complete for each type of equipment now in use by your firm.)

Check Box If Not Applicable	Type of Equipment	Maximum Dollars Per Unit
☐	Cashier or Coin Payer	_____
☐	Coin Sorter	_____
☐	Sorter-Counter	_____
☐	Packager	_____
☐	Other _____	_____
	_____	_____

21. Please estimate the costs which would be incurred by your firm in the first year if a small $1 coin were introduced as a replacement for the existing $1 coin.

Personnel Cost $_____

Equipment and Materials Cost $_____

Total Cost $_____

THANK YOU FOR COMPLETING THE SURVEY ON U.S. COINAGE SYSTEM ALTERNATIVES. IF YOU HAVE ADDITIONAL COMMENTS OR SUGGESTIONS CONCERNING CHANGES IN THE U.S. COINAGE SYSTEM TO 1990 WHICH WOULD BETTER ENABLE YOU TO MEET THE NEEDS OF YOUR CUSTOMERS, PLEASE FURNISH THEM BELOW.

Appendix C

World Coin Denominations by Size and Composition

Table C-1

Coins With Diameters Between 19.25 mm and 21.21 mm

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Germany (FR)	2 pfennig	90% copper clad steel	19.25	1.52
South Africa	10¢	500 Ag, 500 Cu	19.3	1.04
Malawi	5 tambala	75% Cu, 25% Ni	19.4	1.40
Rhodesia	Sixpence	75% Cu, 25% Ni	19.4	1.47
Australia	5¢	75% Cu, 25% Ni	19.41	1.35
Brunei	10 sen	75% Cu, 25% Zn	19.41	1.10
Cyprus	5 mils	75% Cu, 25% Ni	19.41	1.32
Fiji	5¢	75% Cu, 25% Ni	19.41	n.a.
Ghana	5 pesewas	75% Cu, 25% Ni	19.41	1.3
Jamaica	5¢	75% Cu, 25% Ni	19.41	1.09
Malaysia	10¢	75% Cu, 25% Ni	19.41	1.35
Singapore	10¢	75% Cu, 25% Ni	19.41	1.40
Tonga	5 seniti	75% Cu, 25% Al	19.41	n.a.
United Kingdom and Northern Ireland	Sixpence	75% Cu, 25% Ni	19.41	1.40
Western Samoa	5 sene	75% Cu, 25% Ni	19.41	n.a.
Zambia	5 ngwee	60% Cu, 20% Ni, 20% Zn	19.41	1.42
New Zealand	5¢	75% Cu, 25% Ni	19.43	1.35
Austria	50 groschen	91.5% Cu, 8.5% Al	19.5	1.5
Czechoslovakia	20 heller	79% Cu, 20% Zn, 1% Ni	19.5	1.0
France	1/2 franc	Ni	19.5	2.1
Kuwait	5 fils	79% Cu, 20% Zn, 1% Sn	19.5	1.22
Monaco	1/2 franc	Ni	19.5	2.1
Saudi Arabia	5 halala	75% Cu, 25% Ni	19.5	1.2
Ghana	2-1/2 pesewas	75% Cu, 25% Ni	19.51	1.4
Guyana	5¢	79% Cu, 20% Zn, 1% Ni	19.51	1.22

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Yemen	1 fil	97% Al, 3% Mg	19.81	n.a.
Haiti	5 centimes	70% Cu, 18% Zn, 12% Ni	19.99	n.a.
Liberia	5¢	75% Cu, 25% Ni	19.99	1.73
El Salvador	50 centavos	Ni	19.99	n.a.
Afghanistan	25 pul	Al	20.0	1.2
Africa, Equatorial	5 francs	92% Cu, 6% Al, 2% Ni	20.0	1.7
Africa, West	5 francs	92% Cu, 6% Al, 20% Ni	20.0	1.61
Austria	10 groschen	98.5% Al, 1.5% Mg	20.0	1.6
Bahrain	50 fils	75% Cu, 25% Ni	20.0	n.a.
Chile	20 centesimos	92% Cu, 6% Al, 2% Ni	20.0	1.2
	2 centesimos	92% Cu, 8% Al	20.0	1.18
Comoro Islands	10 francs	92% Cu, 6% Al, 2% Ni	20.0	n.a.
Czechoslovakia	5 heller	97.6% Al, 2% Mg, 0.4% Mn	20.0	1.0
Ethiopia	5¢	95% Cu, 5% Zn	20.0	1.88
Finland	10 pennia	93% Cu, 5% Al, 2% Ni	20.0	1.5
France	10 centimes	92% Cu, 6% Al, 2% Ni	20.0	1.5
Germany	50 pfennig	75% Cu, 25% Ni	20.0	1.58
Greece	1 drachma	79% Cu, 20% Zn, 1% Ni	20.0	1.5
	10 lepta	95% Al, 5% Mg	20.0	1.6
	5 lepta	95% Al, 5% Mg	20.0	1.1
Guatemala	1 centavo	70% Cu, 30% Zn	20.0	1.42
Guinea	5 francs	75% Cu, 25% Ni	20.0	1.52
Haiti	5 centimes	75% Cu, 25% Ni	20.0	1.1
Honduras	2 centavos	95% Cu, 5% Sn	20.0	1.5

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
India	2 paise	Al w/3.5% - 4% Mg	20.0	1.75
Indonesia	25 rupiah	75% Cu, 25% Ni	20.0	1.56
Iran	30 dinars	91.5% Cu, 85% Al	20.0	n.a.
Iraq	25 fils	75% Cu, 25% Ni	20.0	1.24
Israel	1 agora	97% Al, 13% mg	20.0	1.35
Jordan	20 fils	75% Cu, 25% Ni	20.0	1.6
Kuwait	20 fils	75% Cu, 25% Ni	20.0	1.32
Libya	10 dirhams	75% Cu, 25% Ni	20.0	1.5
Malagasy Republic	10 francs	91% Cu, 9% Al	20.0	1.7
Mali	5 francs	Mn	20.0	1.7
Monaco	10 centimes	92% Cu, 6% Al, 2% Ni	20.0	1.5
Morocco	10 francs	92% Cu, 6% Al, 2% Ni	20.0	1.6
Netherlands (Antilles)	25¢	Ni	20.0	1.6
New Hebrides	5 francs	92% Cu, 6% Al,	20.0	n.a.
Nicaragua	10 centavos	Ni clad steel	20.0	1.8
Pakistan	25 paisa	75% Cu, 25% Ni	20.0	1.75
Poland	20 grosz	Al	20.0	1.5
Portugal	2-1/2 escudos	75% Cu, 25% Ni	20.0	1.5
Cape Verde	50 centavos	95% Cu, 3% Zn, 2% Sn	20.0	1.5
Portuguese West Africa	2-1/2 escudos	650 Ag, 350 Cu	20.0	1.4
Qatar	25 dirhams	75% Cu, 25% Ni	20.0	1.32
Reunion	10 francs	91% Cu, 9% Al	20.0	n.a.
Spain	50 centimos	96.5% Al, 3.5% mg	20.0	1.25
Sudan	2 piastres	75% Cu, 25% Ni	20.0	1.1
Surinam	25¢	75% Cu, 25% Ni	20.0	1.5
Syrian Arab Republic	25 piastres	600 Ag, 400 Cu	20.0	.83-.84
Trinidad and Tobago	25¢	75% Cu, 25% Ni	20.0	1.63
United Arab Emirates	25 fils	75% Cu, 25% Ni	20.0	n.a.

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
United Arab Republic	5 milliemes	95.5% Cu, 3% Sn, 1.5% Zn	20.0	1.5
Uruguay	5 pesos	92% Cu, 6% Al, 2% Ni	20.0	1.22
Venezuela	1/2 bolivar	Ni	20.0	1.40
Belize	5¢	79% Cu, 20% Zn, 1% Ni	20.19	1.32
Ghana	1/2 pesewa	97% Cu, 2.5% Zn, 0.5% Sn	20.19	1.2
Sierra Leone	1/2¢	97% Cu, 2.5% Zn, 0.5% Sn	20.19	0.99
Rhodesia	1/2¢	95% Cu, 4.5% Zn, 0.5% Sn	20.2	n.a.
San Marino	5 lire	96.2% Al, 3.5% mg, 0.3% Mn	20.3	1.5
Vatican City	5 Vatican lire	96.2% Al, 3.5% Mg, 0.3% Mn	20.3	1.5
Jersey	1 new penny	97% Cu, 2.5% Zn, 0.5% Sn	20.32	1.27
Hungary	20 fillér	97% Al, 3% Mg	20.4	1.4
Korea	5 won	65% Cu, 35% Zn	20.4	n.a.
Ajman	1 riyal	640 Ag, 360 Cu	20.5	1.5
Argentina	50 centavos	92% Cu, 6% Al, 2% Ni	20.5	1.6
Nepal	Panch paise (5 pice)	Al	20.5	1.31
Portugal	20 centavos	95% Cu, 3% Zn, 2% Sn	20.5	1.3
Mozambique	20 centavos	95% Cu, 3% Zn, 2% Sn	20.5	1.3

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Angola	20 centavos	95% Cu, 3% Zn, 2% Sn	20.5	1.3
Cape Verde	20 centavos	95% Cu, 3% Zn, 2% Sn	20.5	1.3
Thailand	25 stangs	91% Cu, 9% Al	20.5	1.2
Hong Kong	10¢	79% Cu, 20% Zn, 1% Ni	20.6	1.98
Pakistan	1 paisa	79% Cu, 20% Zn, 1% Ni	20.6	0.76
South Africa	10¢	Ni	20.7	1.35
Swaziland	10¢	800 Ag, 200 Cu	20.7	n.a.
Iceland	5 kronur	75% Cu, 25% Ni	20.75	1.7
Cayman Islands	10¢	75% Cu, 25% Ni	20.96	n.a.
Kenya	50¢	75% Cu, 25% Ni	20.96	1.32
Tanzania	50 senti	75% Cu, 25% Ni	20.96	n.a.
Yemen	25 fils	75% Cu, 25% Ni	20.96	n.a.
Algeria	5 centimes	95% Al, mg, other metals 5%	21.0	0.99
Argentina	5 pesos	Nickel clad steel	21.0	1.8
Barbados	5¢	80% Cu, 20% Zn	21.0	n.a.
Belgium	1 franc	75% Cu, 25% Ni	21.0	1.51
Brazil	5 centavos	Stainless steel	21.0	1.0
Caribbean	5¢	79% Cu, 20% Zn, 1% Ni	21.0	2.0
Colombia	5 centavos	Nickel clad steel	21.0	1.3
	5 centavos	95% Cu, 5% Ni	21.0	1.6
	5 centavos	75% Cu, 25% Ni	21.0	1.6

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Denmark	2 ore	Zn	21.0	1.55
Ecuador	20 centavos	Nickel clad steel	21.0	1.7
Greece	1 drachma	79% Cu, 20% Zn, 1% Ni	21.0	1.7
Guatemala	10 centavos	720 Ag, 280 Cu	21.0	1.4
	1 centavo	70% Cu, 30% Zn	21.0	1.35
Guernsey	Threepence	75% Cu, 25% Ni	21.0	n.a.
Honduras	5 centavos	75% Cu, 25% Ni	21.0	2.0
Japan	50 yen	75% Cu, 25% Ni	21.0	1.75
Kuwait	10 fils	79% Cu, 20% Zn, 1% Sn	21.0	1.52
Lebanon	10 piastres	92% Cu, 6% Al, 2% Ni	21.0	n.a.
Luxembourg	1 franc	75% Cu, 25% Ni	21.0	1.5
Malagasy Republic	10 francs	92% Cu, 6% Al, 2% Ni	21.0	1.7
Nepal	Das paise	66% Cu, 34% Zn	21.0	1.34
Netherlands	5¢	95% Cu, 4% Sn, 1% Zn	21.0	1.5
Norway	2 ore	95% Cu, 4% Sn, 1% Zn	21.0	1.5
Pakistan	5 paisa	79% Cu, 20% Zn, 1% Sn	21.0	1.5
Peru	25 centavos	70% Cu, 30% Zn	21.0	1.07
Phillippines	25 sentimos	70% Cu, 18% Zn,	21.0	1.75
Rhodesia	Half penny	97% Cu, 2.5% Zn, 0.5% Sn	21.0	n.a.
	Half penny	95.5% Cu, 3% Sn, 1.5% Zn	21.0	1.24

Table C-1 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Rwanda, Republic of	1 franc	75% Cu, 25% Ni Al w/2.8% - 4% mg	21.0 21.0	1.20 1.45
Spain	1 peseta	92% Cu, 6% Al, 2% Ni	21.0	1.33
Switzerland	20 centimes	75% Cu, 25% Ni	21.0	1.8
Syrian Arab Republic	10 piastres 10 piastres 2-1/2 piastres	75% Cu, 25% Ni 92% Cu, 8% Al Bronze-aluminum	21.0 21.0 21.0	1.5 1.5 1.5
Tunisia	2 millimes	95.35% Al, 4% Mg, 0.6% Mn, .05% Cu	21.0	n.a.
Turkey	10 kurus	97% Cu, 2.5% Zn, 0.5% Sn	21.0	1.5
United Arab Republic	5 milliemes 5 milliemes	75% Cu, 25% Ni 92% Cu, 8% Al	21.0 21.0	1.3 1.33
Venezuela	10 centimos	75% Cu, 25% Ni	21.0	1.52
Yugoslavia	10 paras	85% Cu, 14.5% Zn, 0.5% Al	21.0	1.25
Zaire	1 likuta	97% Al, 3% Mg	21.0	1.65
Bahamas	5¢	75% Cu, 25% Ni	21.01	n.a.
Fiji	2¢	97% Cu, 2.5% Zn, 0.5% Sn	21.08	n.a.
Jamaica	1¢	97% Cu, 2.5% Zn, 0.5% Sn	21.08	1.35
New Zealand	2¢	97% Cu, 2.5% Zn, 0.5% Sn	21.08	1.60
Zambia	2 ngwee	97% Cu, 2.5% Zn, 0.5% Sn	21.08	n.a.
Somali Republic	50 centesimi	75% Cu, 25% Ni	21.11	n.a.

Source: U.S. Department of the Treasury, Annual Report of the Director of the Mint for the fiscal year ended June 30, 1974, Doc. No. 3267, Government Printing Office, 1975.

Table C-2

Coins With Diameters Between 25.5 mm and 28.0 mm

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Afars and Issas	50 francs	75% Cu, 25% Ni	25.5	n.a.
Africa, Equatorial States	100 francs	Ni	25.5	1.9
Argentina	25 pesos	Ni Clad Steel	25.5	2.0
	1 peso	Ni Clad Steel	25.5	2.0
Caribbean	1¢	97% Cu, 2.5% Zn 0.5% Sn	25.5	1.6
	1¢	95.5% Cu, 1.5% Zn	25.5	1.6
Denmark	1 kroner	75% Cu, 25% Ni	25.5	1.85
Guatemala	2 centavos	79% Cu, 20% Zn 1% Ni	25.5	1.60
Guernsey	4 doubles	95.5% Cu, 3% Sn, 1.5% Zn	25.5	n.a.
Israel	25 agorot	92% Cu, 6% Al 2% Ni	25.5	1.9
Peru	5 soles	70% Cu, 30% Zn	25.5	1.81
	1 sol	70% Cu, 30% Zn	25.5	n.a.
Rwanda	5 francs	95% Cu, 3% Sn 2% Zn	25.5	1.5
South Africa	1/2¢	75% Cu, 24.5% Zn, 0.5% Sn	25.5	1.22
Vietnam	10 piastres	Ni Clad Steel	25.5	1.27
	10 piastres	75% Cu, 25% Ni	25.5	n.a.
Yugoslavia	50 paras	85% Cu, 14.5% Zn, 0.5% Al	25.5	1.57
Gambia	10 butus	79% Cu, 20% Zn 1% Ni	25.91	n.a.
Guernsey	2 new pence	97% Cu, 2.5% Zn, 0.5% Sn	25.91	1.80
Ireland	2 new pence	97% Cu, 2.5% Zn, 0.5% Ni	25.91	1.78
Isle of Man	2 new pence	97% Cu, 2.5% Zn, 0.5% Ni	25.91	n.a.
Jersey	2 new pence	97% Cu, 2.5% Zn, 0.5% Sn	25.91	1.55

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Malta	1¢	97% Cu, 2.5% Zn, 0.5% Sn	25.91	n.a.
United Kingdom	2 new pence	97% Cu, 2.5% Zn, 0.5% Sn	25.91	1.80
Africa, West	100 francs	Ni	26.0	2.0
Burma	50 pyas	75% Cu, 25% Ni	26.0	1.93
Costa Rica	50 centimos	75% Cu, 25% Ni	26.0	1.70
Czechoslovakia	5 crowns	80% Cu, 20% Ni	26.0	1.50
Ecuador	1 sucre	Nickel Clad Steel	26.0	1.95
El Salvador	10 centavos	75% Cu, 25% Ni	26.0	2.50
Ethiopia	25¢	95% Cu, 5% Zn	26.0	1.82
	25¢	95% Cu, 5% Zn, 5% Sn	26.0	1.82
Fiji	1¢	75% Cu, 25% Ni	26.0	1.98
Guyana	50¢	75% Cu, 25% Ni	26.0	1.85
Haiti	20 centimes	75% Cu, 25% Ni	26.0	1.8
Honduras	10 centavos	75% Cu, 25% Ni	26.0	2.0
India	10 paise	Al. with 3.5% - 4% Mg	26.0	2.25
Indonesia	200 rupiah	Ag	26.0	n.a.
	2 rupiah	Al. Alloy	26.0	n.a.
Iran	750 rials	900 Au	26.0	n.a.
	25 rials	999 Ag	26.0	n.a.
Iraq	10 fils	75% Cu, 25% Ni	26.0	n.a.
	10 fils	Stainless Steel	26.0	n.a.
Jordan	50 fils	75% Cu, 25% Ni	26.0	1.9
Korea	2,500 won	900 Au, 100 Cu	26.0	n.a.
Kuwait	100 fils	75% Cu, 25% Ni	26.0	1.68
Malta	5 mils	Al	26.0	n.a.
Nicaragua	50 centavos	75% Cu, 25% Ni	26.0	2.0
Portugal	1 escudo	95% Cu, 3% Zn, 2% Sn	26.0	2.1

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Angola	1 escudo	95% Cu, 3% Zn, 2% Sn	26.0	2.1
Cape Verde	1 escudo	61% Cu, 20% Zn, 19% Ni	26.0	1.8
Guinea	1 escudo	95% Cu, 3% Zn, 2% Sn	26.0	7.1
SanSome and Principe	1 escudo	95% Cu, 3% Zn, 2% Sn	26.0	1.8
Saudi Arabia	2 girsh	75% Cu, 25% Ni	26.0	1.2
	50 halala	75% Cu, 25% Ni	26.0	1.70
Uganda	1 shilling	75% Cu, 25% Ni	26.0	1.80
United Arab Republic	10 piastres	625 Ag, 375 Cu	26.0	1.35
	5 piastres	833-1/3 Ag, 166-2/3 Cu	26.0	1.30
Trinidad and Tobago	50¢	75% Cu, 25% Ni	26.01	1.85
Haiti	20 centimes	70% Cu, 18% Zn, 12% Ni	26.2	1.9
Finland	5 markka	93% Cu, 5% Al, 2% Ni	26.3	2.05
Guernsey	4 doubles	95% Cu, 4% Sn, 1% Zn	26.4	n.a.
Peru	20 soles	900 Ag, 100 Cu	26.4	1.42
Reunion	100 francs	Ni	26.5	n.a.
Spain	25 pesetas	75% Cu, 25% Ni	26.5	1.73
Vatican City	5 vatican lire	"Italma" (96.2% Al, 3.5% Mg, 0.3% Mn)	26.7	1.8
Federal Republic of Germany	2 Deutsche Mark	75% Cu, 25% Ni	26.75	1.79
	2 Deutsche Mark	75% Cu, 25% ni, Clad Ni	26.75	1.79
Portugal	1 escudo	95% Cu, 3% Zn, 2% Sn	26.8	2.0
Somali	1 shilling	75% Cu, 25% Ni	26.79	n.a.
Tinior	60 centavos	95% Cu, 3% Zn, 2% Sn	26.8	2.0
Cape Verde	1 escudo	61% Cu, 20% Zn, 19% Ni	26.8	1.6

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Guinea	1 escudo	95% Cu, 3% Zn, 2% Sn	26.8	1.6
SanSome and Principe	1 escudo	61% Cu, 20% Zn, 19% Ni	26.8	1.6
Nigeria	florin	75% Cu, 25% Ni	26.92	2.6
Africa, Equatorial States	25 francs	92% Cu, 6% Al, 2% Ni	27.0	2.35
	2 francs	95% Al, 5% Mg	27.0	2.00
Africa, West	25 francs	92% Cu, 6% Al, 2% Ni	27.0	2.25
	2 francs	95% Ni, 5% Mg	27.0	1.60
Austria	10 shillings	640 Ag, 360 Cu	27.0	1.60
Belgium	10 francs	Ni	27.0	1.9
Bolivia	1 peso-boliviano	Ni Clad Steel	27.0	1.57
Brazil	50 centavos	75% Cu, 25% Ni	27.0	1.50
Cambodia	20 sen	95% Al, 5% Mg	27.0	2.05
Chile	10 centesimos	92% Cu, 8% Al	27.0	1.75
Comoro Islands	2 francs	95% Al, 5% Mg	27.0	n.a.
French Polynesia	2 francs	95% Al, 5% Mg	27.0	1.9
Greece	10 drachmas	75% Cu, 25% Ni	27.0	1.90
Guatemala	25 centavos	61% Cu, 20% Zn, 19% Ni	27.0	2.00
	25 centavos	720 Ag, 280 Cu	27.0	1.75
Guinea	25 francs	75% Cu, 25% Ni	27.0	2.03
Israel	100 pounds	900 Au, 100 Cu	27.0	n.a.
Luxembourg	10 francs	Ni	27.0	2.00
Malagasy Republic	2 francs	95% Al, 5% Mg	27.0	1.90
Mali	25 francs	Al	27.0	1.6
Morocco	200 francs	720 Ag, 280 Cu	27.0	1.70
	50 francs	92% Cu, 6% Al, 2% Ni	27.0	2.20
New Caledonia	2 francs	95% Al, 5% Mg	27.0	n.a.
Norway	5 ore	95% Cu, 4% Sn, 1% Zn	27.0	1.75
Poland	2 zloty	Al	27.0	2.30

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Qatar	10 dirhams	97% Cu, 2.5% Zn, 0.5% Sn	27.0	n.a.
Reunion	2 francs	95% Al, 5% Mg	27.0	n.a.
Rhodesia	one penny	95.5% Cu, 3% Sn, 1.5% Zn	27.0	1.68
	one penny	97% Cu, 2.5% Zn, 0.5% Sn	27.0	1.68
Saint Pierre Et Miquelon	2 francs	95% Al, 5% Mg	27.0	n.a.
Sweden	5 ore	95% Cu, 4% Sn, 1% Zn	27.0	1.93
	5 ore	Iron	27.0	1.92
Switzerland	2 francs	75% Cu, 25% Ni	27.0	2.15
	2 francs	835 Ag, 165 Cu	27.0	2.15
Thailand	5 baht	75% Cu, 25% Ni	27.0	n.a.
	1 baht	75% Cu, 25% Ni	27.0	1.51
	1 baht	75% Cu, 25% Ni	27.0	1.51
Tunisia	1 dinar	Mixed Metals	27.0	n.a.
	100 millimes	69%-72% Cu, 31%-28% Zn	27.0	n.a.
Turkey	1 lira	"Acmonital" Steel	27.0	2.07
United Arab Emirates	10 fils	97% Cu, 2.5% Zn, 0.5% Sn	27.0	n.a.
United Arab Republic	10 piastres	720 Ag, 280 Cu	27.0	1.3-1.4
Venezuela	2 bolivars	Ni	27.0	2.0
Vietnam	20/100 piastres	95% Al, 5% Mg	27.0	2.06
Yugoslavia	20 dinar	91% Cu, 9% Al	27.0	n.a.
Cayman Islands	25 dollars	500 Au	27.10	n.a.
Jamaica	20 dollars	500 Au	27.10	n.a.
Canada	50¢	Ni	27.13	1.88
Brazil	300 cruzeiros	920 Au	27.5	1.80
Israel	1 pound	75% Cu, 25% Ni	27.5	2.20

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Nepal	Dabal (1 rupee)	75% Cu, 25% Ni	27.5	1.85
Phillippines	50 sentimos	70% Cu, 18% Zn, 12% Ni	27.5	1.96
Uruguay	100 pesos	70% Cu, 20% Ni, 10% Zn	27.5	1.40
Yugoslavia	5 dinar	70% Cu, 18% Zn, 12% Ni	27.5	1.75
Sudan	10 piastres	75% Cu, 25% Ni	27.7	1.89
Belize	50¢	75% Cu, 25% Ni	27.74	n.a.
Kenya	1 shilling	75% Cu, 25% Ni	27.74	1.45
Tanzania	1 shilling	75% Cu, 25% Ni	27.74	n.a.
Yemen	50 fils	75% Cu, 25% Ni	27.74	n.a.
Brunei	50 sen	75% Cu, 25% Zn	27.76	1.73
Malaysia	100 dollars	917 Au, 83 Cu	27.76	2.21
	50¢	75% Cu, 25% Ni	27.76	2.16
Mauritius	200 rupees	916.6 Au	27.76	n.a.
Singapore	50¢	75% Cu, 25% Ni	27.76	2.03
Italy	100 lire	"Acmonital" (Steel Containing 18% chrome)	27.8	2.0
San Marino	100 lire	"Acmonital" (Steel containing 18% chrome)	27.8	2.0
South Africa	50¢	Ni	27.84	1.75
Nigeria	penny	97% Cu, 2.5% Zn, 0.5% Sn	27.94	1.9
Pakistan	1 rupee	Ni	27.94	2.39
Bahamas	100 dollars	585 Au	28.0	n.a.
	100 dollars	750 Au	28.0	n.a.
Burundi	10 francs	75% Cu, 25% Ni	28.0	1.8
Colombia	2,000 pesos	900 Au	28.0	n.a.
	300 pesos	900 Au	28.0	1.75
Greece	5 drachmas	75% Cu, 25% Ni	28.0	2.00
Hungary	10 forint	Ni	28.0	1.90

Table C-2 (con.)

Country	Denomination	Material Composition	Diameter (mm)	Thickness (mm)
Iceland	2 kronur	92% Cu, 6% Al, 2% Ni	28.0	2.08
Japan	100 yen	75% Cu, 25% Ni	28.00	2.00
Jordan	10 fils	97% Cu, 2.5% Zn, 0.5% Sn	28.0	2.2
	10 fils	95.5% Cu, 3% Sn, 1.5% Zn	28.0	2.2
Lebanon	1 livre	Ni	28.0	n.a.
Netherland Antilles	1 guilder	720 Ag, 280 Cu	28.0	2.0
	1 guilder	Ni	28.0	2.1
Peru	1 sol	70% Cu, 30% Zn	28.0	1.72
Poland	10 zloty	Cu/Ni% n.a.	28.0	2.2
Portugal	10 escudos	75% Cu, 25% Ni, Clad Ni	28.0	2.2
Mozambique	10 escudos	75% Cu, 25% Ni	28.0	2.0
	10 escudos	75% Cu, 25% Ni	28.0	2.1
Portuguese Timor	1 escudo	95% Cu, 3% Zn, 2% Sn	28.0	2.10
	10 escudos	75% Cu, 25% Ni	28.0	2.0
Angola	10 escudos	75% Cu, 25% Ni	28.0	2.0
Guinea	10 escudos	75% Cu, 25% Ni	28.0	1.2
SanSome and Principe	10 escudos	75% Cu, 25% Ni	28.0	2.0
Surinam	1 guilder	720 Ag, 280 Cu	28.0	2.0
Swaziland	50¢	800 Ag, 200 Cu	28.0	n.a.
Syrian Arab Republic	100 piastres	680 Ag, 320 Cu	28.0	2.0
Uruguay	10 pesos	92% Cu, 6% Al, 2% Ni	28.0	2.25
Zaire	10 makuta	75% Cu, 25% Ni	28.0	2.0

Source: U.S. Department of the Treasury, Annual Report of the Director of the Mint, for the fiscal year ended June 30, 1974, Document No. 3267, Government Printing Office, 1975.

Appendix D

Comparative Analysis of Minimum and Maximum Coin Denominations in the U.S. and Seven Countries

Appendix D

Comparative Analysis of Minimum and Maximum Coin Denominations in the U.S. and Seven Countries

1.0 INTRODUCTION

The objective of this appendix is to examine information which would help determine the optimum value and level of minimum and maximum denominations in a coinage system for exchange in commercial transactions. The discussion will include a description of the relative values of the minimum and maximum denominations in the United States and seven other countries. The trends in the purchase power of the minimum and maximum denomination in the United States will be described. Finally, the relative production and circulation levels of the minimum and maximum denominations in the United States and other countries will be examined.

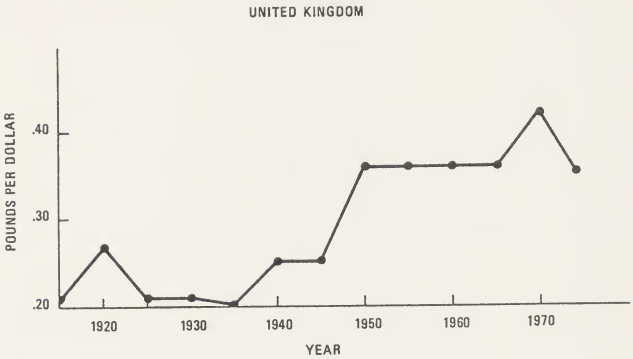
2.0 RELATIVE VALUES OF MINIMUM AND MAXIMUM DENOMINATIONS IN THE UNITED STATES AND OTHER COUNTRIES

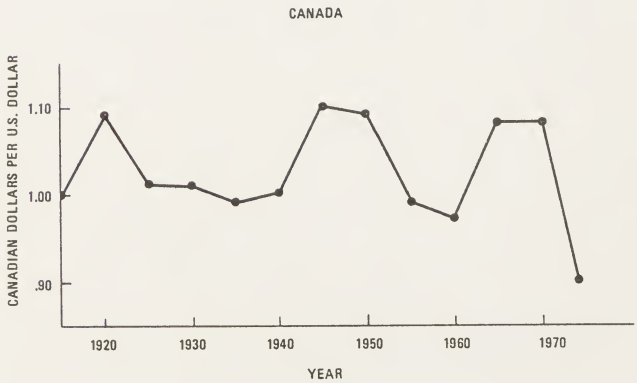
One way to consider the relative values of minimum and maximum denominations in the United States and other countries is to consider each in terms of a constant base value such as the German mark or the U.S. dollar. Using the U.S. dollar as such a constant, computations have been generated on the Exchange Rate of seven foreign currencies and the value in U.S. dollars of the minimum and maximum denominations from 1915-1974. However, Exhibits 1 through 5 and Tables 1 through 7 indicate extreme inconsistency in Exchange Rate trends over time and acorss the seven countries examined. The inconsistency observed may be attributed in part to domestic as well as international economic and political variables. Consequently, the results of this comparison are inconclusive with respect to employing the U.S. dollar as an indicator of the relative value of foreign currencies. Other measures must be considered.

3.0 TRENDS IN PURCHASE POWER OF U.S. AND FOREIGN MINIMUM AND MAXIMUM COIN DENOMINATIONS

Another way to evaluate the relative value of foreign currency is to consider the purchase power of the minimum and maximum denominations of a

EXHIBIT 1
EXCHANGE RATES





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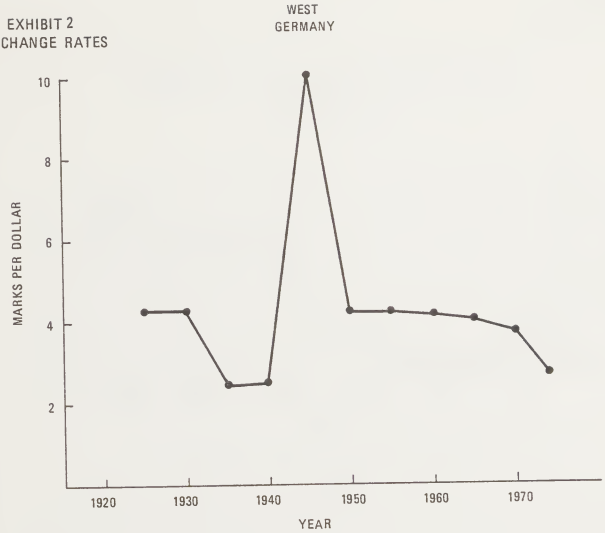

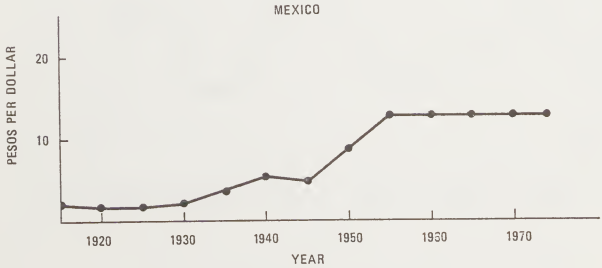

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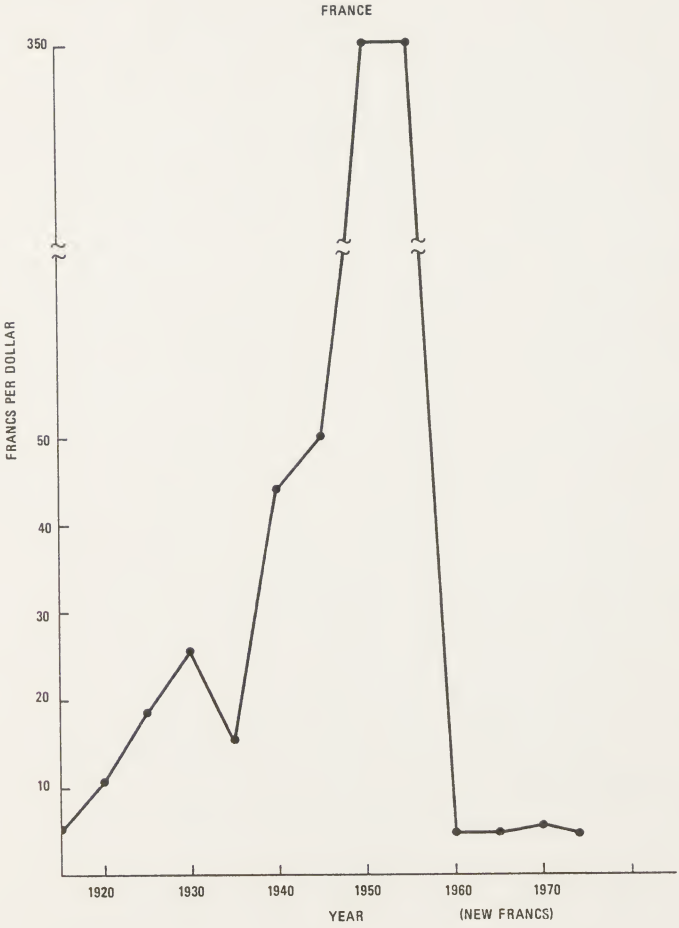

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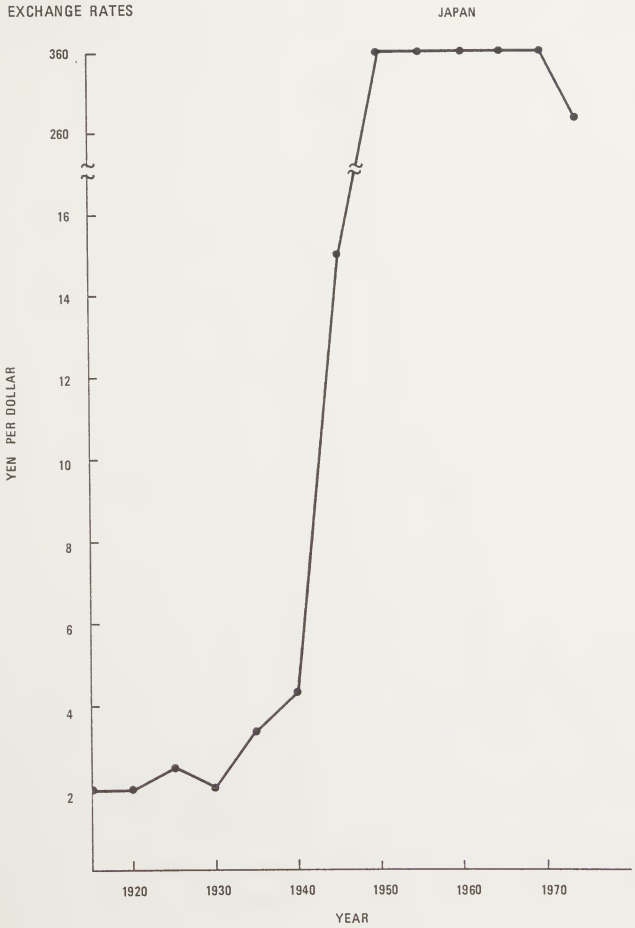

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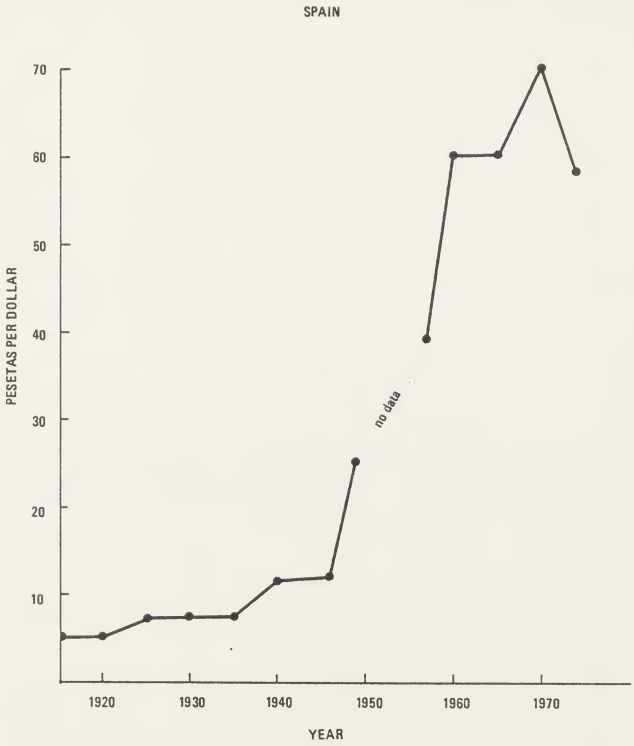

Table 1

Exchange Rates

CANADA

Base Denomination: Dollar

Year	Value in Canadian Dollars: Minimum Denomination	Value in Canadian Dollars: Maximum Denomination	Exchange Rate: Canadian $/ U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.01	.50	1.00	.010	.50
1920			1.09	.009	.459
1925			1.01	.010	.495
1930			1.01	.010	.495
1935		1.00	.99	.010	1.010
1940			1.00	.010	1.00
1945			1.10	.009	.909
1950			1.09	.009	.917
1955			.99	.010	1.010
1960			.97	.010	1.031
1965			1.08	.009	.926
1970			1.08	.009	.926
1974			.90	.011	1.11

Table 2

Exchange Rates

FRANCE

Base Denomination: Franc

Year	Value in Francs: Minimum Denomination	Value in Francs: Maximum Denomination	Exchange Rate: Francs / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.01		5.24	.002	
1920	.01		10.75	.001	
1925	.05		18.59	.003	
1930	.05	100.0	25.50	.002	3.922
1935	.05	100.0	15.31	.003	6.532
1940	.10		43.80	.002	
1945	.10		49.72	.002	
1950	1.00	50.00	350.00	.003	.143
1955	NA	100.0	349.95	NA	.286
1960[1/]	.01	5.00	4.90	.002	1.020
1965		10.00	4.94	.002	2.024
1970			5.55	.002	1.802
1974			4.60	.002	2.174

[1/] New francs.

Table 3

Exchange Rates

JAPAN

Base Denomination: Yen

Year	Value in Yen: Minimum Denomination	Value in Yen: Maximum Denomination	Exchange Rate: Yen / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.01	20.00	2.00	.005	10.00
1920		20.00	2.00	.005	10.00
1925		NA	2.53	.004	NA
1930		20.00	2.00	.005	10.00
1935		NA	3.40	.003	NA
1940		NA	4.26	.002	NA
1945		NA	15.00	.001	NA
1950	1.00	5.00	360.00	.003	.014
1955		50.00	360.00	.003	.139
1960		100.00	360.00	.003	.278
1965			360.00	.003	.278
1970			360.00	.003	.278
1974			277.20	.004	.361

Table 4

Exchange Rates

MEXICO

Base Denomination: Peso

Year	Value in Pesos: Minimum Denomination	Value in Pesos: Maximum Denomination	Exchange Rate: Pesos / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.01	1.00	2.00	.005	.500
1920			1.80	.006	.556
1925			1.69	.006	.592
1930			2.00	.005	.500
1935			3.60	.003	.278
1940			5.18	.002	.193
1945			4.86	.002	.206
1950			8.65	.001	.116
1955			12.49	.001	.080
1960			12.49	.001	.080
1965			12.50	.001	.080
1970			12.50	.001	.080
1974			12.50	.001	.080

Table 5

Exchange Rates

SPAIN

Base Denomination: Pesetas

Year	Value in Pesetas: Minimum Denomination	Value in Pesetas: Maximum Denomination	Exchange Rate: Pesetas / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.01	NA	5.24	.002	NA
1920	NA	NA	5.27	NA	NA
1925	.25	NA	7.15	.035	NA
1930	.25	NA	7.53	.033	NA
1935		1.00 (1934)	7.46	.034	.134
1940	.05	NA	11.67	.004	NA
1945	.05	1.00 (1944)	11.95	.004	.084
1950	.50	5.00	25.00	.020	.2
1955		50.00 (1957)	NA	NA	NA
1960	.10	50.00	60.00	.002	.833
1965	.50	100.00 (1966)	59.99	.008	1.669
1970	.50	100.00	70.00	.007	1.429
1974	.50	100.00	58.00	.009	1.724

Table 6

Exchange Rates

UNITED KINGDOM

Base Denomination: Pound

Year	Value in Pounds: Minimum Denomination	Value in Pounds: Maximum Denomination	Exchange Rate: Pounds / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1915	.00104	1.00	4.76	.005	4.762
1920		.125	3.70	.004	.463
1925		1.00	4.76	.005	4.762
1930		.25	4.77	.005	1.190
1935		.25	5.00	.005	1.25
1940		.125	4.00	.004	0.5
1945			4.00	.004	0.5
1950			2.77	.003	.347
1955			2.77	.003	.347
1960	.00208	1.00	2.77	.006	2.78
1965	.00208	1.00	2.77	.006	2.78
1970[1/]	.005	1.00	2.38	.012	2.38
1974	.005	.50	2.86	.014	1.429

[1/] Changed to decimal coins (100 Pence = 1 Pound).

Table 7

Exchange Rates

WEST GERMANY

Base Denomination: Mark

Year	Value in Marks: Minimum Denomination	Value in Marks: Maximum Denomination	Exchange Rate: Marks / U.S. $	Value in U.S. Dollars: Minimum Denomination	Value in U.S. Dollars: Maximum Denomination
1945	.01	.10	10.00	.001	.01
1950		5.00	4.20	.002	1.190
1955		5.00	4.20	.002	1.190
1960			4.17	.002	1.199
1965			4.00	.003	1.25
1970			3.66	.003	1.366
1974			2.67	.004	1.873

currency relative to a cost-of-living index for that country. However, in order to compare the purchase power of a denomination in one country with the purchase power of a denomination in another country, each currency must be computed against a cost-of-living index which is constant with respect to the items composing the index and the data-gathering techniques employed to measure each item in the index.

Derived from data obtained in the United Nations Statistical Yearbook,[1/] Table 8 shows that from 1940-1971 the percent increase in the cost-of-living index in the eight countries examined ranged from a low of 152.0 percent in Canada to a high of 3325.0 percent in France.[2/]

3.1 Maximum Denomination

Using the cost-of-living indices as a base, computations were derived with respect to the purchase power of the maximum denominations in the eight countries examined. One strategy for changing the maximum denomination in a country would be to do so in response to cost-of-living changes so that the denomination would "purchase" a relatively constant amount of goods and services over time. In spite of the extreme cost-of-living increases shown in Table 8, only five of the eight countries, France,[3/] Japan, Spain, the United Kingdom, and West Germany, have increased the value of the maximum coin denomination relative to the base denomination of their currency and relative to its purchase power (see Table 9).

[1/] The data for all international comparisons are obtained from the Statistical Yearbook, Statistical Office of the United Nations, Department of Economic and Social Affairs. The data are furnished to the Statistical Office by the International Labor Office. Please note that there are many irregularities in the composition of the index and in the data-gathering techniques employed to measure each item in the index.

[2/] The percent increase in the United Kingdom and Japan's cost-of-living index is very great. However, no comparable data were available prior to 1948 for the United Kingdom, and 1946 for Japan.

[3/] In 1960, France devalued its currency such that 100.0 "old" francs became equal to 1.0 "new" franc. Therefore, the introduction of a 5.0-franc coin in 1960 represents a 500.0 percent increase in the maximum coin denomination relative to the base denomination (1.0 "new" franc).

Table 8

Cost of Living[1/], 1940-1971[2/]

Year	Canada	France	Japan	Mexico	Spain	U.K.	U.S.	West Germany
1940	*51.5*	*4.0*		*13.2*	*18.8*		*38.5*	
1941	54.4	4.6		13.5	26.3		41.9	
1942	57.3	5.4		15.4	27.9		49.4	
1943	57.9	7.0		19.8	27.2		54.8	
1944	57.9	8.6		25.5	28.3		54.0	
1945	58.4	11.7		27.5	30.4		55.2	
1946	60.4	20.1	29.8	35.7	43.0		63.6	
1947	66.3	32.5	28.4	41.0	50.9		77.0	
1948	*75.7*	*51.8*	*50.4*	*43.2*	*52.5*	*75.0*	*83.7*	*68.9*
1949	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
1951	85.3	66.0	65.5	53.4	66.6	94.5	91.0	81.5
1952	87.9	72.4	67.7	62.4	64.0	71.2	92.8	85.7
1953	87.0	71	72	60	64	75	91	84
1954	87.9	72.4	77.8	62.4	64.6	77.3	91	85.7
1955	87.9	73.8	75.6	73.8	67.2	82.5	89.2	87.4
1956	88.7	75.3	74.9	78.6	72.3	-	90.1	89.0
1957	92.2	77.4	77.8	83.4	81.3	-	92.8	91.6
1958	94.0	79.5	76.3	93.0	93.4	-	97.4	94.1
1959	95.7	-	-	-	99.8	-	95.6	-
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
1962	98.0	95	91	100	91	98	99	97
1963	100	100	100	100	100	100	100	100
1964	102	104	104	102	105	103	101	102
1965	104	106	113	106	122	106	104	106
1966	108	109	117	112	127	110	109	109
1967	112	111	123	115	132	113	110	109
1968	117	114	131	118	138	118	114	108
1969	122	121	139	121	141	125	119	111
1970	126	129	151	128	146	134	126	114
1971	130	137	160	131	157	148	130	118
1971	*130*	*137*	*160*	*131*	*157*	*148*	*130*	*118*
Since 1940								
% Change	+152	+3325	-	+892	+735	-	+238	-
Since 1948								
% Change	+72	+164	+217	+203	+199	+97	+55	+71

1/ The cost-of-living indexes are obtained from the Statistical Yearbook; Statistical Office of the United Nations, Department of Economic and Social Affairs. 1963 = 100. Please note that there are many irregularities in the composition of the index and in the data-gathering techniques employed to measure each item in the index.

2/ 1971 is the last year for which comparable price index figures are available.

Table 9

Purchase Power[1] of the Maximum Coin Denomination, 1948-1971[2]

Year	Canada	France	Japan	Mexico	Spain	U.K.	U.S.	W. Germany
				Base Denomination				
	Dollar	Franc	Yen	Peso	Peseta	Pound	Dollar	Mark
	(1.00)[3]	*(100.00)*	*(20.00)*	*(1.00)*	*(1.00)*	*(.125)*	*(.50)*[5]	*(.10)*
1948	1.32	193.0	39.7	2.31	1.90	.167	.60	.145
1949	-	-	-	-	-	-	-	-
		(50.00)	*(5.00)*		*(5.00)*			*(5.00)*
1950	-	-	-	-	-	-	-	-
1951	1.17	75.7	7.63	1.87	7.51	.132	.55	6.13
1952	1.14	69.0	7.39	1.60	7.81	.176	.54	5.83
1953	1.15	70.4	6.94	1.67	7.81	.167	.55	5.95
1954	1.14	69.0	6.43	1.60	7.74	.162	.55	5.83
		(100.00)	*(50.00)*					
1955	1.14	135	66.1	1.36	7.44	.152	.56	5.72
1956	1.13	133	66.8	1.27	6.92	-	.55	5.62
					(50.00)			
1957	1.08	129	64.3	1.20	61.5	-	.54	5.46
1958	1.06	126	65.5	1.08	53.5	-	.51	5.31
1959	1.04	-	-	-	50.1	-	.52	-
		(5.00)[4]	*(100.00)*			*(1.00)*		
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
1962	1.02	5.26	100.0	1.00	54.9	1.02	.50	5.15
1963	1.00	5.00	100.0	1.00	50.0	1.00	.50	5.00
1965	.961	4.72	88.5	.943	41.0	.973	.48	4.72
				(100.00)	*(100.00)*			
1966	.926	4.59	88.5	.893	78.7	.909	.46	4.59
1967	.893	4.50	81.3	.870	75.7	.885	.45	4.59
1968	.855	4.39	76.3	.847	72.5	.847	.44	4.63
1969	.820	4.13	71.9	.826	70.9	.800	.42	4.50
1970	.794	3.87	66.2	.781	68.5	.746	.40	4.39
1971	770	3.65	62.5	.763	63.7	.676	.38	4.24
% Change[6]	-42	-98	+57	-67	+3353	+305	-37	+2824

Footnotes are on page D-15.

Table 9 Footnotes

1/ Purchase power is obtained by dividing the price index for a 1963 base period (100.0) by the price index for a given period and expressing the result in terms of the maximum denomination of each country.

2/ Data for many countries are extremely incomplete prior to 1948. 1971 is the last year for which comparable price index figures are available.

3/ The number in parentheses represents the value of the maximum denomination in terms of the base denomination of a particular currency.

4/ "New" francs.

5/ The one dollar coin was not introduced until late in 1971. This figure represents the purchase power of the half dollar.

6/ Percent change in purchase power of the maximum denomination 1948-1971.

SOURCE: Statistical Yearbook Statistical Office of the United Nations, Department of Economic and Social Affairs.

According to the United Nation's data (Table 8), the cost-of-living in the United States increased 237.7 percent between 1940 and 1971 and 55.3 percent between 1948 and 1971. According to the more accurate Consumer Price Index published by the U.S. Bureau of Labor Statistics (see Table 10), the cost-of-living in the United States increased 188.0 percent from 1940 to 1971 and 68.33 percent between 1948 and 1971.[1/] (Table 10 also indicates that the cost-of-living has increased 251.8 percent between 1940 and 1974.) However, according to the U.N. data (Table 9), the purchase power of the U.S. half dollar decreased 36.6 percent between 1948 and 1971. Data from the U.S. Bureau of Labor Statistics (Table 10) indicate that the purchase power of the half dollar decreased 40.5 percent during the same time. (The purchase power of the half dollar decreased 65.4 percent between 1940 and 1971 and 71.6 percent between 1940 and 1974.)

In other words, the cost-of-living in the United States has increased steadily since 1940. Yet, the purchase power of the maximum denomination ($.50) relative to the U.S. base denomination ($1.00) has remained constant (until 1971 when the composite dollar coin was introduced) and it has decreased 65.4 percent in purchase power between 1940 and 1974 (see Table 10).

3.2 Minimum Denomination

As evidenced in Table 8 the cost-of-living has increased steadily in the eight countries observed. Table 11 indicates that five countries have changed their minimum denominations since 1948. Of these, four countries--Japan, Spain, the United Kingdom, and West Germany--have increased value relative to the base denomination.[2/] Consequently, only these four countries currently maintain a minimum denomination which has increased in purchase power since 1948 in spite of the continually rising cost-of-living.

[1/] Table 3 indicates the percent change in Consumer Price Index and Purchase Power from 1940-1974, 1940-1971, and 1948-1971 in order to facilitate comparisons between the two data sources.

[2/] In 1960 France devalued its currency such that 100.0 "old" francs become equal to 1.0 "new" francs. Therefore, the introduction of a .01-franc coin in 1960 does not represent an increase in the minimum coin denomination relative to the base denomination.

Table 10

Consumer Price Index and Purchase Power of the Dollar: 1940-1974[1/]

Year	CPI[2/]	Purchase Power[3/]	
		$(1.00)¢	$(.50)
1940	*41.99*	*2.381*	*1.19*
1945	53.90	1.855	.928
1947	66.88	1.495	.748
1948	*72.09*	*1.387*	*.693*
1949	71.37	1.401	.700
1950	72.09	1.387	.693
1951	77.82	1.285	.642
1952	79.49	1.258	.629
1953	80.12	1.248	.624
1954	80.51	1.242	.624
1955	80.19	1.247	.623
1956	81.36	1.229	.614
1957	53.76	1.86	.930
1958	64.51	1.55	.775
1959	87.33	1.145	.572
1960	88.73	1.127	.563
1961	89.60	1.116	.558
1962	90.57	1.104	.552
1963	91.65	1.091	.545
1964	92.93	1.076	.538
1965	94.51	1.058	.529
1966	97.18	1.029	.514
1967	100.00	1.000	.50
1968	104.16	.960	.480
1969	109.76	.911	.455
1970	116.27	.860	.430
1971	*121.35*	*.824*	*.412*
1972	125.15	.799	.399
1973	133.15	.751	.375
1974	*147.71*	*.677*	*.338*
1940-1974 % Change	+251.77	-71.57	-71.57
1940-1971 % Change	+188.0	-65.39	-65.38
1948-1971 % Change	+68.33	-40.59	-40.55

1/ SOURCE: U.S. Bureau of Labor Statistics, monthly data in U.S. Bureau of Economic Analysis, "Survey of Current Business."

2/ Consumer Price Index 1967 = 100. Prices prior to 1964 exclude Alaska and Hawaii.

3/ Obtained by dividing the average price index for 1967 base period (100.00) by the price index for a given period and expressing the result in dollars and cents.

According to the United Nations data, between 1948 and 1971, the purchase power of the penny decreased from 1.2 cents to .8 cents or 33.3 percent in value (see Table 11). In comparison, the U.S. Bureau of Labor Statistics Consumer Price Index data in Table 3, show that the penny decreased from 1.4 cents to .8 cents or 40.6 percent in value during the same period of time. Table 2 also shows that between 1940 and 1974 the penny's decrease in value is more drastic. Its drop from 2.4 cents to .7 cents represents a 71 percent decrease in purchase power (also see Exhibit 6). It is interesting to note that it would take more than a nickel today to purchase what a penny would in 1917.

4.0 PRODUCTION AND CIRCULATION LEVELS OF THE MINIMUM AND MAXIMUM DENOMINATIONS IN THE UNITED STATES AND OTHER COUNTRIES

The final topic to be addressed in this paper is the relative production and circulation levels of the minimum and maximum denominations over time and across the eight countries being evaluated. One method by which to compare production and circulation levels in spite of the wide variation in each country's population is to derive a "coin stock per capita" figure for the minimum and maximum denominations produced in each country.

Table 12 indicates the level of production for the minimum and maximum denomination, the population, and the coin stock per capita of these denominations in 1960 and 1970. Production levels for 1958 through 1962 and 1968 through 1972 were added then divided respectively by the population in 1960 and 1970. Five years were considered in order to minimize erratic figures and provide a more realistic estimate of the number of coins in circulation.

4.1 Maximum Denomination

The findings with respect to the coin stock per capita of the maximum denominations are inconclusive. There is a slightly positive relationship between cost-of-living increases and increases in per capita production across the eight countries examined. This conforms to the hypothesis that the value and/or production of the maximum denomination in a country should change in response to changes in the cost-of-living in that country.

Table 11

Purchase Power[1/] of the Minimum Coin Denomination, 1948-1971[2/]

Year	Canada Dollar	France Franc	Japan Yen	Mexico Peso	Spain Peseta	U.K. Pound	U.S. Dollar	W. Germany Mark
				Base Denomination				
	(.01)[3/]	*(.10)*	*(.01)*	*(.01)*	*(.05)*	*(.00104)*	*(.01)*	*(.01)*
1948	.013	.019	.020	.023	.095	.001	.012	.014
1949	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
		(1.00)	*(1.00)*		*(.50)*			*(5.00)*
1951	.012	1.51	1.52	.019	.751	.001	.011	6.13
1952	.011	1.38	1.48	.016	.781	.001	.010	5.83
1953	.011	1.41	1.39	.017	.781	.001	.011	5.95
1954	.011	1.38	1.28	.016	.774	.001	.010	5.83
1955	.011	1.35	1.32	.013	.744	.001	.011	5.72
1956	.011	1.33	1.33	.013	.691	-	.011	5.62
1957	.011	1.29	1.28	.012	.615	-	.011	5.46
1958	.011	1.26	1.31	.011	.535	-	.010	5.31
1959	.010	-	-	-	.501	-	.010	-
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
		(.01)[4/]				*(.00208)*		
1962	.010	.010	1.10	.010	.510	.002	.010	5.15
1963	.010	.010	1.00	.010	.500	.002	.010	5.00
1964	.010	.010	.961	.010	.476	.002	.010	4.90
1965	.010	.009	.885	.009	.410	.002	.010	4.72
1966	.009	.009	.855	.009	.394	.002	.009	4.59
1967	.009	.009	.813	.009	.374	.002	.009	4.59
1968	.008	.009	.763	.008	.362	.002	.009	4.63
1969	.008	.009	.720	.008	.355	.002	.008	4.50
						(.005)		
1970	.008	.008	.662	.008	.342	.004	.008	4.39
1971	.008	.008	.625	.008	.318	.003	.008	4.24
[5/] % Change	-38.46	-57.89	+3025.00	-65.21	+234.73	+200	-33.33	+30,185.

Footnotes are on page D-20

Table 11

FOOTNOTES - MINIMUM DENOMINATION

1/ Purchase Power is obtained by dividing the price index for a 1963 base period (100.0) by the price index for a given period and expressing the result in terms of the minimum denomination of each country.

2/ Data for many countries are extremely incomplete prior to 1948. 1971 is the last year for which comparable price index figures are available.

3/ The number in parentheses represents the value of the minimum denomination in terms of the base denomination of a particular currency.

4/ "New" francs.

5/ Percent change in purchase power of the minimum denomination 1948-1971.

SOURCE: Statistical Yearbook; Statistical Office of the United Nations, Department of Economic and Social Affairs.

EXHIBIT 6
TREND IN PURCHASE POWER OF U.S. $1 AND 1¢ COINS

As described previously, five of the eight countries have increased the value of the maximum denomination since 1948. Furthermore, the increase in the cost-of-living was found to be the greatest in Japan, Mexico, France, and Spain. Exhibit 7 indicates that, in fact, Japan, Mexico, and France circulate more maximum denomination coins per capita than the other countries.[1/] The U.S. per capita coin stock of the half dollar is moderately low compared to the countries with more extreme increases in cost-of-living. Note, however, that the per capita coin stock levels of maximum denominations were relatively similar in all eight countries. In every country observed, coin stock levels ranged from approximately 1 to 15 maximum denomination coins per person. As indicated in the next section, Table 12, and Exhibit 8, this is not the case with the per capita coin stock levels of minimum denomination coins.

In addition to changes in the cost-of-living, there are many other factors which may influence the per capita coin stock level of the maximum denomination. One such factor is the rate of circulation. Frequently features such as coin size, shape, and weight affect its circulation and, eventually, production level. As indicated in other sections of the Coin Study, these factors do play a part in the circulation and production of the maximum denomination in the United States.

4.2 Minimum Denomination

The findings with respect to the per capita coin stock of the minimum denomination are twofold. There is a slightly inverse relationship between per capita production of the minimum denomination and changes in the cost-of-living in a country. However, in contrast with the per capita coin stock levels of maximum denominations, the per capita coin stock levels of minimum denominations do not fall into a narrow range for all eight countries. Table 12 and Exhibit 8 show conclusively that in 1960 and 1970 the number of pennies in circulation per capita in Canada to a lesser degree and the United States to a greater degree far exceeded the number of minimum denomination coins circulating per capita in any other country. In 1960, the per capita coin stock of minimum denominations ranged from approximately 1 to 20 coins per person in all countries except Canada where

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[1/] No comparable data are available for Spain.

EXHIBIT 7

MAXIMUM DENOMINATION COIN STOCK PER CAPITA
IN THE UNITED STATES AND SIX COUNTRIES

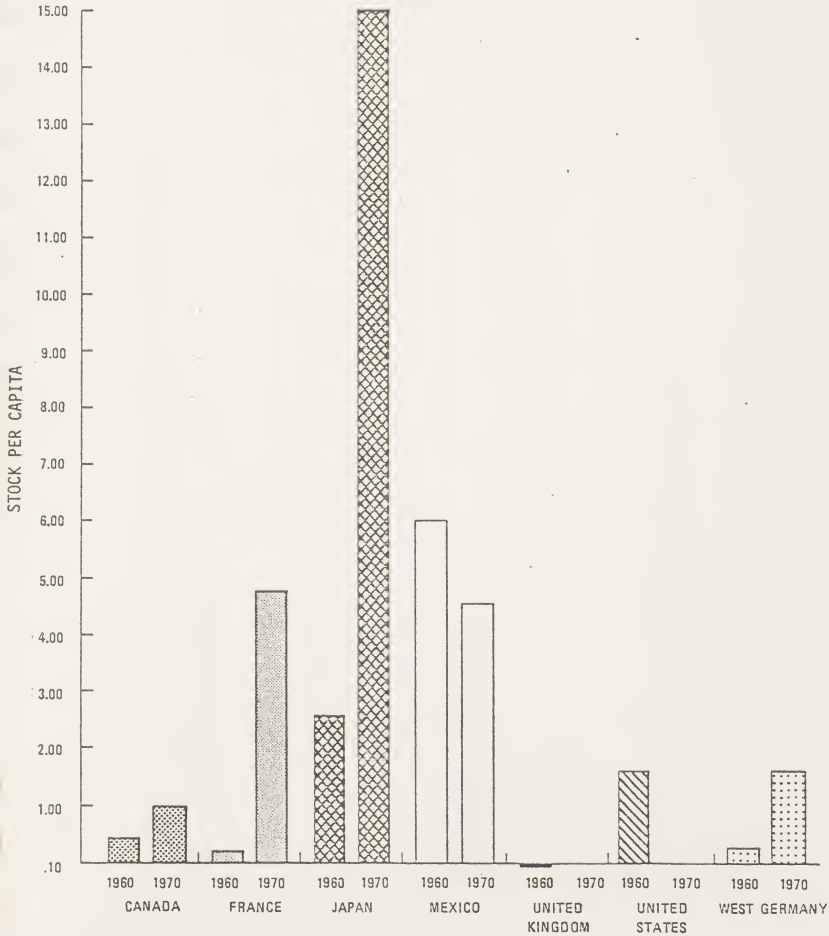

EXHIBIT 8

MINIMUM DENOMINATION COIN STOCK PER CAPITA
IN THE UNITED STATES AND SIX COUNTRIES

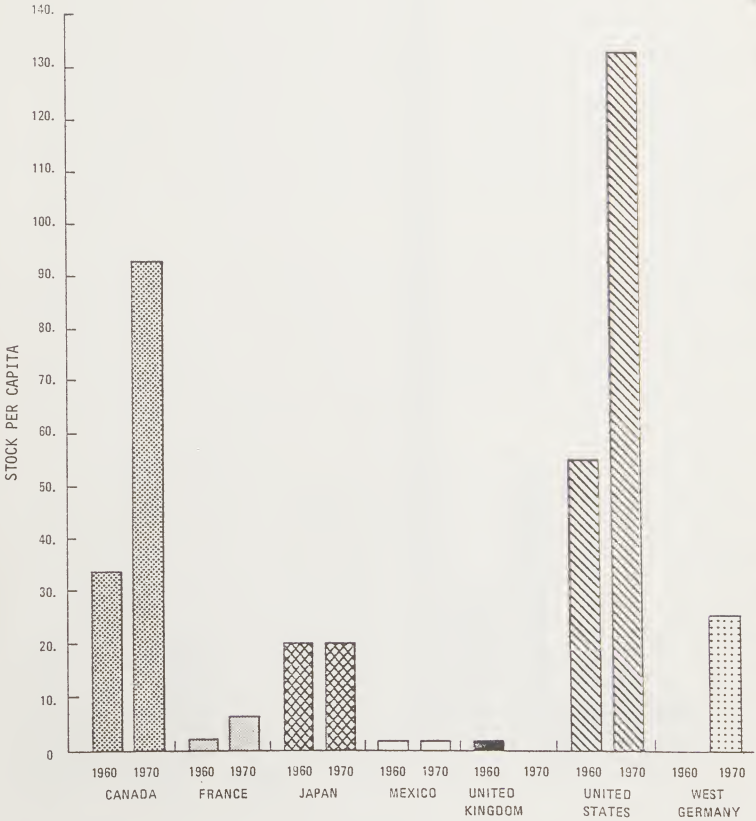

Table 12

Coin Stock Levels of Minimum and Maximum Denominations

		Coin Stock (millions)			Coin Stock/Capita[6]	
		MIN DENOM	MAX DENOM	POP(Mill)	MIN DENOM	MAX DENOM
Canada	1960	585.616	7.788	17.814	32.874	0.437
	1970	1,954.386	21.466	21.324	91.622	1.007
France	1960[1]	82.0	8.1	45.542	1.800	0.178
	1970	337.9	246.14	50.768	6.656	4.848
Japan	1960	1,890.0	245.0	93.419	20.231	2.623
	1970	2,120.0[2]	1,551.0[4]	104.345	20.3	14.864
Mexico	1960	45.64	209.22	34.923	1.307	5.991
	1970	4.04[4]	222.72[5]	48.225	0.083	4.618
Spain	1960	NA	NA	30.431	NA	NA
	1970	NA	NA	30.041	NA	NA
U.K.	1960	63.14[7]	5.07[8]	52.539	1.202	.096
	1970	NA	NA	55.411	NA	NA
U.S.	1960	10,026.007	155.213	183.285	54.701	1.693[9]
	1970	27,366.142	NA[9]	207.976	131.583	NA[9]
W. Germany	1960	NA	12.17[3]	53.373	NA	0.228
	1970	1,600.0	103.77	60.651	26.380	1.711

[1] France changed to the "new" franc system in 1960. Mintage of centimes did not begin until 1962 and coins before 1960 are not of comparable value. Coin stock figures for "1960" are averages of 1962 and 1965 only.

[2] Does not include 1968 and 1971 - no data available.

[3] Does not include 1962 - no data available.

[4] Does not include 1971 - no data available.

[5] Includes 1970 and 1972 only - no other data available.

[6] Coin stock/capita figures for 1960 were derived by adding the total production from 1958-1962 and dividing by 1960 population. Figures for 1970 were derived by adding the total production from 1968-1972 and dividing by 1970 population.

[7] Half penny data from 1955 and 1960 only.

[8] Sovreign data from 1957 and 1972 only.

[9] Half dollars were not produced between 1966 and 1971.

the coin stock was at 33 pennies per person and in the United States where coin stock was clearly the highest at 55 pennies per person. In 1970, the coin stock level of minimum denominations ranged from approximately 1 to 25 coins per person except in Canada where coin stock was at 92 pennies per person and in the United States where coin stock was again exceptionally high at 132 pennies per person. It is anticipated that this trend will continue. In 1975 the annual production per capita of the penny was 44. Employing population and production projections for 1980 and 1990 it is evident that at 70 and 153 respectively, the annual projected per capita production of the penny for these years will greatly exceed current production levels.

As in the case of the maximum denomination, it must be noted that there are factors aside from changes in cost-of-living which could contribute to this phenomenon in Canada and in the United States. One such factor is the fact that of all the countries considered, only the United States and Canada have not increased the value of the minimum denomination relative to the base denomination in spite of its steady decrease in purchase power. Other factors might include coin material composition, pricing structures, and numismatic interests.

5.0 CONCLUSIONS

- In Section 1.0, it was stated that the objective of this paper is to examine information from Canada, France, Japan, Mexico, Spain, the United Kingdom, the United States, and West Germany which would help determine the optimum value and level of minimum and maximum denominations in a coinage system for exchange in commercial transactions.
- In Section 2.0, it was discovered that the Exchange Rate is an inadequate tool for measuring the relative values of minimum and maximum denominations in the United States and the seven other countries examined.
- Findings in Section 3.0 indicate that in spite of high cost-of-living increases experienced by all eight countries, only five of these countries--France, Japan, Spain, the United Kingdom, and West Germany--have increased the value of the maximum coin denomination relative to the base denomination of their currency and relative to its purchase power. Furthermore, only four countries--Japan, Spain, the United Kingdom, and West Germany--have

increased the value of the minimum coin denomination relative to the base denomination of their currency and relative to its purchase power.

- Findings in Section 4.0 reveal that there is a slightly positive relationship between cost-of-living increases and increases in per capita coin stock levels of the maximum denomination in the eight countries examined. In 1970, per capita coin stock levels of the maximum denomination ranged between approximately 1 and 15 coins per person in every country examined.
- The most important findings in Section 4.0 are that in 1970 the range of per capita coin stock of minimum denominations was similar to maximum denomination coin stock levels (between 1 and 20 coins per person) in every country except Canada and the United States. *In 1970, Canada was circulating 92 pennies per capita, and in the same year, the United States was circulating 132 pennies per capita.* Estimates for 1980 and 1990 indicate that production per capita will be much greater in the future.

Appendix E

Attendees at One Dollar Coin Meeting at
Research Triangle Institute
June 22, 1976

Attendees at One Dollar Coin Meeting at
Research Triangle Institute
June 22, 1976

Name	Organization
David H. Stuart	Research Triangle Institute
M. Anne Hill	Research Triangle Institute
Steven Johnston	Research Triangle Institute
Anne H. Devries	U.S. Bureau of the Mint
Alan Goldman	U.S. Bureau of the Mint
Deborah Duke Swann	U.S. Bureau of the Mint
Robert K. Wilcox	U.S. Bureau of Engraving and Printing
Roy C. Cahoon	National Automatic Merchandising Assoc.
Richard Funk	National Automatic Merchandising Assoc.
Barton C. Conant	Abbott Coin Counters Co.
Pete V. Petropoulos	Amiel Industries
John P. Ellis	Bell Telephone Laboratories
Roy W. DeMeyer	Brandt, Inc.
Harold Brogden	Canteen Corporation
J. Leo Levasseur	Coin Acceptors
Claude Trieman	Coin Acceptors
Fred Heiman	Mars Money Systems
Jim Sturdy	National Rejectors
Jim Schuller	National Vendors
Marvin Manzer	Reed Industries
Wilbur O. Wachter	Servomation
Kit E. Pennell	Vendo

Appendix F

Cost Comparison of Alternatives to the Copper Cent

Table F

Cost Comparison of Alternatives to the Copper Cent

Present Cent						
Year	Coin Requirements (billion coins)	Percent of coins manufactured that add to circulation	Total Costs (million dollars)	Difference Between Face Value and Total Costs (million dollars)	Total Costs Per Coin Produced	Total Costs Per Coin Added to Circulation
1975	9.4	31.8	81.2	13.0	0.009	0.027
1978	12.7	30.7	135.8	-8.8	0.011	0.036
1979	14.1	29.8	159.5	-18.5	0.011	0.037
1980	15.6	28.2	188.9	-32.9	0.012	0.043
1981	17.2	27.3	214.2	-42.2	0.012	0.044
1982	18.9	26.5	249.2	-60.2	0.013	0.049
1983	20.8	25.0	289.5	-81.5	0.014	0.056
1984	22.8	24.1	332.1	-104.1	0.015	0.062
1985	24.9	22.9	390.0	-141.0	0.016	0.068
1986	27.1	21.8	437.3	-166.3	0.016	0.073
1987	29.5	20.8	487.2	-192.2	0.017	0.079
1988	32.1	19.6	554.0	-233.0	0.017	0.087
1989	34.7	18.7	619.9	-272.9	0.018	0.096
1990	37.6	17.8	695.8	-319.8	0.018	0.101

Table F (Continued)

Aluminum Cent						
Year	Coin Requirements (billion coins)	Percent of coins manufactured that add to circulation	Total Costs (million dollars)	Difference Between Face Value and Total Costs (million dollars)	Total Costs Per Coin Produced	Total Costs Per Coin Added to Circulation
1978	18.1	85.1	93.8	87.2	0.005	0.006
1979	18.0	71.6	96.8	83.2	0.005	0.007
1980	18.3	60.0	102.9	80.1	0.006	0.010
1981	25.0	57.6	147.4	102.6	0.006	0.010
1982	22.8	43.0	141.3	86.7	0.006	0.014
1983	25.7	39.3	167.9	89.1	0.007	0.018
1984	22.8	24.1	157.6	70.4	0.007	0.029
1985	24.9	22.9	178.5	70.5	0.007	0.031
1986	27.1	21.8	204.8	66.2	0.008	0.037
1987	29.5	20.8	231.1	63.9	0.008	0.038
1988	32.1	19.6	264.1	56.9	0.008	0.041
1989	34.7	18.7	299.7	47.3	0.009	0.048
1990	37.6	17.8	336.9	39.1	0.009	0.051

Table F (Continued)

Two Cent Coin							
Year	Coin Requirements (billion coins)		Percent of coins manufactured that add to circulation	Total Costs (million dollars)	Difference Between Face Value and Total Costs (million dollars)	Total Costs Per Coin Produced	Total Costs Per Coin Added to Circulation
	Cent	2 Cent					
1978	4.0	6.5	13.3	85.2	84.8	0.005	0.038
1979	4.0	7.2	16.1	94.5	89.5	0.005	0.031
1980	4.0	6.6	17.9	96.0	76.0	0.006	0.034
1981	4.0	7.4	20.2	105.1	82.9	0.006	0.030
1982	4.0	8.0	20.8	115.8	84.2	0.006	0.029
1983	4.0	8.7	21.3	128.1	85.9	0.006	0.028
1984	4.0	9.6	19.9	141.1	90.9	0.006	0.030
1985	4.0	10.4	22.2	156.7	91.3	0.006	0.027
1986	4.0	11.2	22.4	171.2	92.8	0.006	0.027
1987	4.0	12.1	34.7	186.7	95.3	0.007	0.020
1988	4.0	13.0	22.4	205.0	95.0	0.007	0.031
1989	6.4	12.5	24.3	250.9	63.1	0.008	0.033
1990	7.5	13.0	23.9	288.9	46.1	0.009	0.038

Table F (Continued)

Elimination of the Cent						
Year	Coin Requirements (billion coins)	Percent of coins manufactured that add to circulation	Total Costs (million dollars)	Difference Between Face Value and Total Costs (million dollars)	Total Costs Per Coin Produced	Total Costs Per Coin Added to Circulation
1978	7.75	22	80.3	117.7	0.010	0.045
1979	1.80	100	31.7	111.3	0.018	0.018
1980	1.85	100	34.2	110.8	0.018	0.018
1981	1.90	100	36.7	113.3	0.019	0.019
1982	2.00	100	41.4	115.6	0.021	0.021
1983	2.05	100	43.9	118.1	0.021	0.021
1984	2.10	100	47.5	117.5	0.023	0.023
1985	2.15	100	47.6	122.4	0.022	0.022
1986	2.25	100	55.1	122.9	0.024	0.024
1987	2.30	100	58.9	124.1	0.026	0.026
1988	2.35	100	62.6	122.4	0.027	0.027
1989	2.40	100	66.5	123.5	0.028	0.028
1990	2.50	100	72.6	124.4	0.029	0.029